THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL.

VOL. 29. Thursday, May 22, 1924. No. 405.

PUBLISHED WEEKLY.

Subscription Terms: 15s. per annum.
Foreign and Colonial, 17s. 6d. per annum.
All Subscriptions are payable in advance.

All communications to be addressed to the Editor, or to the Publisher, as the case may be, of

THE FOUNDRY TRADE JOURNAL,
BESSEMER HOUSE, 5, DUKE STREET, ADELPHI, LONDON, W.C.2.

Contents.

	PAGE
The Newcastle Conference	413
Fluxes and Slags in Welding	414
Publications Received	416
Foundry Queries	416
Institute of British Foundrymen	416
Dry Sand and Loam Moulding	417
Patent Abstracts	416, 419
Aluminium-Alloy Pistons	420
Research in the Wembley Palace of Engineering	421
Copper-Zinc Alloys which Expand on Solidification	421
Correspondence	422
Iron and Steel Output in April	422
Cast Iron in Motor Car Construction	423
The Use of Fluxes in the Melting of Aluminium and its Alloys	427
Contracts Open	428
Obituary	428
Gazette	428
On the Working Slags in Ferrous Processes	429
Company News	432
Personal	432
Trade Talk	432
Further Carnegie Scholarships	432
Iron and Steel Markets	434

Forthcoming Events.

JUNE 4-5.

British Empire Mining and Metallurgical Conference.—At Wembley.

JUNE 4 to 6.

Institute of British Foundrymen. — Annual Convention at Newcastle.

JUNE 19 to 28.

International Foundry Trades Exhibition.—At Bingley Hall, Birmingham.

JUNE 25 to 27.

Foundry Technical Congress.—Bingley Hall, Birmingham.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

Institute of British Foundrymen.

PRESIDENT, 1923-24, Oliver Stubbs, M.I.Mech.E., Openshaw, Manchester.

LIST OF SECRETARIES—

General Secretary: W. G. Hollinworth, 38, Victoria Street, London, S.W.1.
Lancashire: T. Makemson, 21, Beresford Road, Gorse Hill, Stretford, Manchester.
Birmingham: H. James Roe, 33, Herbert Road, Bearwood, Birmingham.
Sheffield: R. Village, Albion Foundry, Whittington Moor, near Chesterfield.
Scottish: J. Bell, 60, St. Enoch Square, Glasgow.
London: H. G. Sommerfield, Charterhouse Chambers, Charterhouse Square, London, E.C.1.
Newcastle-on-Tyne: H. A. J. Rang, 2, St. Nicholas Buildings, Newcastle-on-Tyne.
East Midlands: H. Bunting, 17, Marcus Street, Derby.
Coventry: J. M. Meston, 37, Melville Road.
West Riding of Yorkshire Branch: A. Love, 232, Gladstone Street, Bradford.
Wales and Monmouth Branch: J. J. McClelland, M.I.Mech.E., Druslyn, Bishops Road, Whitechurch, Glam.

Welsh Engineers' and Founders' Association.

Secretary: F. J. Griffiths, 20, Fisher Street, Swansea.

The Newcastle Conference.

The Newcastle Conference of the Institute of British Foundrymen, to be held during the first week of June, undoubtedly represents the greatest effort that has ever been made to cater for the technical and social advancement of the foundry industry. The works to be visited are amongst the best equipped in the country, and their products are famous throughout the world. No firm in any country is in a position to boast of better metallurgical control than some of these Tyneside foundries, and this feature alone constitutes a very good reason why every foundry in the land should be represented at the Newcastle Conference.

The papers to be submitted compare more than favourably with any list ever submitted to any foundry conference. The one on the nature of graphite strikes at a fundamental principle on which foundrymen build up their notions of quality and other properties of cast iron. What foundryman is not interested in permanent moulds, die casting and long-life moulds? The subject relates to possibilities which are only just becoming to be realised. Surely when this subject is to be dealt with by a metallurgist of international reputation such as Mr. R. J. Anderson, of the American Bureau of Mines, then foundrymen should consider it a privilege to be present and an opportunity not to be missed. Oil sand cores are to be dealt with, and this subject is receiving an added interest because one Midland firm has proved that oil sand cores can be economically used for really large castings. Finality in the subject has not yet been reached, and the discussions on the subject are invariably illuminating. Dutch cupola practice is another subject from which many points may be picked up by British manufacturers, and economy in cupola practice is still of vital importance to most foundries.

Non-ferrous foundrymen are catered for by a Paper on alloys for marine engineering. If foundrymen can satisfy the demands imposed by the shipbuilding industry they will have but little trouble in catering for other trades. They, too, have works visits of an interesting character.

Of the French Exchange paper, the name of its author is sufficient guarantee that it will be of a very high class character and a valuable contribution to the study of ferrous metallurgy as applied to foundry practice.

On the social side, a glance at the programme which has been circularised to members is so convincing that never in the history of the Institution has hospitality been so generously offered, and it is difficult adequately to express the deep debt of gratitude that the foundry world owes to the local reception committee.

There is just one thing that remains to make the Newcastle Conference the outstanding success that it warrants, and that is, true co-operation by the trade, and the only recognition which the organisers expect is a record gathering of foundrymen. We understand that foundrymen applying for membership between now and the Conference will receive an invitation to participate in it. On the side of expense, it is assured that this will be extremely low, thanks to the efforts of the committee in obtaining specially cheap rates from every railway company and the provision of accommodation suitable for all pockets. We appeal to foundry directorates and owners throughout to accord every facility for leave of absence for their representatives to take part in the Conference. We confidently expect that as firms, they will be rewarded by the added experience and knowledge their representatives will gain.

Fluxes and Slags in Welding.*

By W. Spraragen, Secretary, American Bureau of Welding.

[*Abridged.*]

Fluxes in Electric Arc Welding.

In welding by the electric arc, the metal is raised to a very high temperature in an extremely small space of time. A different type of flux might therefore be necessary to react properly in this short space of time, and at this high temperature than would be required with a flux in steel manufacture where the temperature was much lower and the time for reaction much longer.

Proponents for the use of flux and slag-coated wires maintain that covering an electrode with some material which shields it from the air until it is on the verge of the arc prevents much of this oxidation and saves electrode material. It must also have such a composition that it will fuse and combine with the iron oxide to form a light fluid slag which floats on the molten weld metal and does not get entangled with it. It is claimed that the fluid slag protects the hot work of the weld metal from the air and by combining with the oxide present cleans the work surface and promotes the union of the metal projected from the electrode. Some go even as far as to state that the flux covering may be volatilised wholly or partly by the heat of the arc and form a vapour sheath or jacket around the arc preventing access of air to the iron passing through the arc.

Apart from the above action, the use of flux-covered wire is sometimes employed because of the possibility of depositing metal of a composition more like that of the pieces to be joined than would be possible with ordinary bare wire. In passing across the arc the composition of the metal is altered. Carbon, silicon and manganese are, for example, removed, so that there is very little difference in the deposited metal as far as chemical composition is concerned from a pure bare wire or from a manganese mild steel wire. The analysis of electrode material and deposited metal (Table I) brings out clearly the above.

Analyses of Electrode, Per Cent. of Additions.

	C.	M.	P.	S.	S.
Roebling ..	0.16	0.56	0.032	0.024	0.016
Norway ..	0.049	0.021	0.025	0.007	0.08
C.R.S. ..	0.11	0.72	0.097	0.123	0.011
H.R.S. ..	0.13-0.17	0.50	0.012	0.045	0.011
Toncan ..	0.10	0.16	0.010	0.046	trace

Analyses of Deposited Metal, Per Cent. of Additions.

	C.	Mn.	P.	S.	Si.
Roebling ..	0.05	0.18	0.031	0.036	0.011
Norway ..	0.05	0.18	0.020	0.072	0.011
C.R.S. ..	0.05	0.11	0.086	0.072	0.011
H.R.S. ..	0.14	0.14	0.012	0.039	0.011
Toncan ..	0.042	0.081	0.019	0.026	0.000

In some instances, such, as for example, welding cast iron or alloy steels, it may be important from either physical or chemical properties that the weld metal shall be substantially equal to the pieces to be joined. One of the methods that may be employed to impart such qualities to the deposited metal is by reaction with the flux material.

It is also maintained that in alternating current arc welding the use of flux-covered wire will help to maintain the arc. The exact theory is not understood, but it is believed that either the surrounding gases help to maintain the temperature of the arc during the low part of the cycle or that the surrounding vapour itself possesses some conductivity and therefore helps to maintain the arc during this low part of the low voltage curve.

Fluxes may be applied to the electrode in metallic arc welding either through a light or heavy coating. In the case of a light coating, electrodes are dipped in some mixture which on drying leaves a thin skin of the solids in the mixture. In other cases the electrodes are covered with a material of substantial thickness and solidity. Asbestos yarn is sometimes used in the latter case. It is claimed that the asbestos is a valuable flux itself as it fuses and combines with iron oxide into a silicate compound which is easily removed upon solidification. The asbestos yarn also makes possible the addition of other constituents such as mineral salts or other ingredients necessary to bring about the desired composition and quality of the deposited metal. For example, when welding cast iron, one manufacturer has a coating which carries carbon in such a form and quantity as to combine with the metal in the required manner leaving the deposited metal which has a structure typical to cast iron.

Some of the ingredients of the flux coating may be ferro-silicate, sodium silicate, aluminium silicate, aluminium wire. In a book on electric arc welding by E. Wanamaker and H. R. Pennington, an analysis of electrode material and deposited metal (Table II) is given to show the effectiveness of a certain coating to deposit metal high in manganese and carbon content. The author states that the appearance of the weld was perfect, being smooth without gas holes or other imperfections.

Table II.

Element.	Electrode Per Cent.	Deposited Metal Per Cent.
C, ...	0.99	0.71
P, ...	0.043	0.061
S, ...	0.022	0.018
Mn, ...	10.51	10.19

"The Brinell hardness of the head of the rail was 154, and the average hardness of the deposited metal was 156. Due to the extreme toughness of the metal much trouble was experienced in pulverising the deposit for analysis; many tools were broken, and when the sample was finally placed under a steam hammer in an effort to break it up, deep impressions were made in the hammer jaws."

"Another test was conducted to determine the loss of constituents, using electrodes containing alloys in a milder form, and with a very thin coating such as would permit welding in a vertical or horizontal position. The results are given in Table III":—

Element.	Electrode Per Cent.	Deposited Metal Per Cent.
C, ...	0.18	0.15
Mn, ...	0.50	0.40
P, ...	0.012	0.012
S, ...	0.032	0.032
Si, ...	0.140	0.12
Ni, ...	2.97	2.08

Mr. Owens states that the coating is frequently made up with a vehicle having characteristics similar to silicate of soda to which are added various mineral salts having the desired reducing and fluxing properties. The dry coating must adhere closely and at the same time must be relatively thin. In his report to the Welding Committee of the Emergency Fleet Corporation, Mr. R. E. Wagner, of the General Electric Company, states that the best results obtained have been with magnesium and boron sub-oxide used as a core or coating on bare low carbon steel electrodes.

He also states that in electric arc welding of copper and steel they do not make use of any fluxes whatever. In the brazing of copper and brass with town gas or acetylene, borax is used as a flux. Welding of cast iron is done with the acetylene flame. Borax is used, as it causes the impurities in the molten metal to float to the top.

Mr. J. W. Owens, of the Norfolk Navy Yard, comments further on this subject:—

"At the Norfolk Yard we have found that the lime residue obtained from calcium carbide in our acetylene generating plant makes an excellent coating and is used by us when a coating for iron

* Paper read at the recent symposium on Slags and Fluxes, arranged by the Faraday Society, the Institute of Metals, the Institute of British Foundrymen, and the Non-Ferrous Research Association.

or steel electrodes is desired. The electrode is dipped in a thick solution of the sludge as obtained from the plant and allowed to dry on the electrode. No binder is used.

"With some iron and low-carbon steel electrodes, a coating improves their welding characteristics and stabilises the arc at the higher current densities, making it easier to use such currents with an increase in the rate of deposit. We do not find, however, that a coating is necessary on general repair and production work."

Welding Monel Metal.

In a Paper published in the May, 1922, issue of the Journal of the American Welding Society Dr. P. D. Merica, of the International Nickel Company, states that in welding monel metal great difficulty was experienced at first to obtain welds that were sound and free from blow holes, shrinking cracks and ductile. These difficulties were attributed to the fact that the metal melted by the arc absorbed sufficient oxygen from surrounding air making it necessary to re-deoxidise it. The agents which were found superior for the purpose are the same as those used in the foundry in casting monel metal, *i.e.*, magnesium, manganese and silicon. Dr. Merica states that these agents are best employed in the form of alloys ground from 50 to 100 mesh and applied to welding rod of bare monel wire as a thin coating. The binder which they use is made up of denatured alcohol containing one half pound to the gallon of shellac. The exact composition of the coating powder may vary within moderately wide limits, the essential thing being to introduce into the weld metal about the amounts of manganese and silicon and particularly of magnesium which are generally used for deoxidation in the foundry. Thus they introduce from 0.05 to 0.50 per cent. of magnesium from 0.20 to 1 per cent. silicon, and at least 0.20 per cent. of manganese, the upper limit of manganese is not important as an excess is not harmful. The excess of magnesium or silicon, however, would tend to produce dirty or brittle metal respectively.

Welding Cast Iron.

In welding cast iron, particularly if subsequent machining is to be done, the "Welding Encyclopædia" states that good results can be obtained by using a copper-aluminium alloy electrode and a suitable flux. It is comparatively difficult to use this alloy electrode, however, due to its low melting temperature and a tendency to drop off the end of the electrode in large globules. Therefore material greater than $\frac{1}{4}$ in. in thickness must be preheated. An analysis of the electrode shows the presence of 88.48 per cent. copper, 3.32 per cent. iron, 8.14 per cent. aluminium, a trace of zinc and no tin. The flux supplied with the electrode consists of 68.4 per cent. Na_2CO_3, 22.6 per cent. NH_4Cl, and 0.5 per cent. Na_2SO_4. Owing to the characteristics of the electrode, in the flux a considerable amount of slag is formed which is rather difficult to remove from the body of the weld during the operation. Another well-known welding company recommends monel metal covered with a flux.

Good flux for welding cast iron with the carbon arc can be made of a mixture of equal parts of carbonate of soda and bi-carbonate of soda.

With cast iron, the oxide formed is lighter than the melted metal and does not flow at quite so low a temperature. The slag which forms on the surface of the iron therefore tends to hold the melted metal into place. Scaling powder should be added by dipping the rod into the powder, only when the metal does not flow well and no more should be used than is necessary. When using a flux in welding cast iron it will be noticed that as soon as a small portion of it is put on the melted iron, the surface of the metal becomes clear and mirror-like, thus making a good weld possible.

Fluxes in Gas Welding.

Fluxes are sometimes used in oxy-acetylene welding in the form of a powder or incorporated in the welding rod itself. The composition differs for different metals that are welded. In welding cast iron a flux is used for breaking up the oxide of iron which forms as a slag on the surface. Mr. S. W. Miller, in his book on oxy-acetylene welding recommends that the flux be a mixture of equal parts of carbonate of soda and bi-carbonate of soda. He states that a good way to prepare a flux is to grind the washing and baking sodas together in an ordinary meat grinder, passing the material through the hopper two or three times in order to secure a thorough mixture.

The action of the carbonates is to combine with the oxygen in the slag, releasing the iron and allowing the oxygen to pass off in the form of carbon monoxide or carbon dioxide. The same type of flux is sometimes used in welding steel (although successful welds with proper care may be made without its use).

In welding copper, ordinary borax gives very good results, and phosphorus is sometimes incorporated in the welding rod to eliminate occluded gases and blow holes.

Great care must be taken in welding aluminium even with the use of a flux. When aluminium is melted it oxidises freely, and as the outside of the slag is heavier than the melted metal and melts at a much higher temperature, the tendency is for it to become mixed with the molten metal and weaken the weld. To decompose the oxide requires a very chemically active flux. However, with the use of flux difficulty is experienced after a period of time because of the destructive action of the flux on the aluminium itself for some distance from the weld. It is very difficult to reweld a section composed of aluminium which has been previously welded with the use of a flux. In some instances, therefore, it may not be advisable to use it, particularly in the repair of broken parts. In the welding of sheet aluminium, of course, the use of a flux is desirable.

Aluminium Fluxes.

Sample Nos.	1.	2.	3.	4.	5.	6.	7.	8.	9.	11.	12.	13.
Sodium Chloride	30.0	30.0	—	12.5	16.0	17.0	6.5	86.0	16.36	90.0	14.5	86.0
Potassium Chloride ..	45.0	45.0	33.4	62.7	79.0	83.0	56.0	—	—	—	—	—
Lithium Chloride	15.0	15.0	33.3	20.8	—	3	23.5	—	—	—	—	—
Sodium Fluoride	—	—	33.3	—	—	—	—	—	—	—	—	—
Potassium Fluoride ..	7.0	7.0	—	—	—	—	—	—	—	—	—	—
Sodium Bisulphate ..	—	3.0	—	—	—	—	—	—	—	—	—	—
Potassium Bisulphate ..	3.0	—	—	4.0	—	—	—	—	—	—	—	—
Sodium Sulphate	—	—	—	—	—	—	4.0	14.0	3.63	9.0	70.0	14.0
Potassium Sulphate ..	—	—	—	—	5.0	—	—	—	—	—	—	—
Aluminium Sodium Fluoride	—	—	—	—	—	—	10.0	—	—	—	—	—
Borax	—	—	—	—	—	—	—	—	70.0	—	11.7	—
Sodium Carbonate	—	—	—	—	—	—	—	—	70.	—	11.7	—
Sodium Bi-Carbonate ..	—	—	—	—	—	—	—	—	10.01	—	3.5	—

Sample No. 1 devised in France by the Autogenous Welding Association; Nos. 2 to 7 inclusive from "Oxy-Acetylene Welding" by S. W. Miller; and Nos. 8 to 13 inclusive are commercial samples from the Norfolk Navy Yard Tests.

In some cases instructions are issued that after welding is done the piece must be thoroughly washed off with boiling water to remove the remnants of the flux.

Mr. Miller states that good welds can be made without the use of a flux by puddling the weld with a rod made of soft steel about 3-16 in. dia. In his opinion there are two points to be considered in connection with the use of flux. First, all aluminium castings are more or less porous, due to the presence of oxide, and therefore the weld need not be any better than the casting. Second, even by the use of a flux it is not possible to make a perfectly sound weld, although under the best conditions it is somewhat freer from porosity than when made without a flux. He

therefore concludes that the arguments against the use of a flux carry more weight than those in favour of it.

Mr. Owens states that the object of a flux in the case of cast iron is to break up at the fusion temperature the oxide into its component parts. Mr. Owens gives the chemical analysis of fluxes for gas welding in Table III.

TABLE III.—*Chemical Analysis of Fluxes for Gas Welding. Commercial Fluxes for Cast Iron.*

Sample No.	Sodium Carbonate.	Sodium Bi-carbonate.	Sodium Nitrate.	Borax.
1	50.0	50.0	—	—
3	26.6	—	50.00	23.4

Conclusion.

The knowledge of the use of fluxes in welding is in a very unsatisfactory state. Practices are based largely on the results of practical experience where the use of flux has been found to give results which have proved satisfactory in service. Very little scientific effort has been made to analyse the functions of the flux, their best composition, their best methods of application and the results attained from their use. It is believed by some that the use of flux will in some instances give better results than welding without its use. Test results are needed to substantiate these opinions.

Institute of British Foundrymen.

NEWCASTLE BRANCH.—Junior Section.

Members of the junior section and their friends paid a visit to the works of Messrs. the Northern Press Engineering Company, South Shields, on Saturday, May 17, at the invitation of Mr. M. B. Herbst (Manager). Mr. Herbst is the Junior Vice-President of the Newcastle Branch of the I.B.F.

The visitors were taken around the foundry, machine shops and printing works by Mr. Pearson (under-manager), Mr. Thomson (foundry-foreman) and Mr. Tate (chief compositor). They were shown the manufacture of printing machinery from the foundry to the erected and finished machine, and, finally, they had the privilege of seeing a printing press in operation. It may be mentioned that this firm prints several local newspapers.

The visit proved exceedingly interesting, and the visitors were afterwards entertained to tea.

Foundry Queries.

Cold Metal.

The difficulty experienced by J. R. R. in the temperature of his metal is one common to many foundries in their cupola working. Economical cupola melting can only be obtained by following certain well defined conditions, among these as affecting J. R. R. are running a properly designed cupola, efficient blowing installation, and carrying out a correct method of charging the fuel.

As J. R. R. gives no details of his charges or the height from the bottom of his cupola to tuyere level (a very important factor in his case), a brief outline can only be given as to the practice he should follow to secure satisfactory melting conditions.

J. R. R. is hampered to some extent by his fan being alternating-current driven; a variable speed motor is the only practical method, as a correct resistance is essential where a specific volume and pressure of blast are required; a constant volume of blast under all practical conditions must be obtained if regular hot metal is required.

The volume of air as used by J. R. R. for his 24-in. cupola, viz., 2,000 cub. ft. per min., is too excessive. The melting capacity is about 2 tons per hour, the coke consumption per hour should be about 500 lbs. The amount of air required to consume 112 lbs. coke is in the neighbourhood of 15,000 cub. ft.; the amount for each ton of iron melted varies with the fuel consumed, but can be taken as a standard as 30,000 to 35,000 cub. ft. When more air than can be utilised is forced into a cupola extra heat is absorbed, and obviously it must increase the retarding of melting, for its influence is to reduce the temperature. There is such a thing as delivering too much air into a cupola. It should be remembered that whenever the blast goes into a cupola it cools off the fuel and the melting iron falls upon this lifeless fuel and is chilled by the direct force of the excessive cold blast. The volume of air required by J. R. R. should not exceed 1,200 cub. ft. per min.

Assuming that the height from bottom of this cupola to tuyere level is normal, viz., 18 to 20 in., the height from tuyere level to coke bed charge should not exceed 18 in. These depths will give hotter metal and less charged with iron oxides. The coke bed, as given by J. R. R., is far too excessive. Deep walls generally give cooler metal, and create higher sulphur and carbon content.

The number of tuyeres required for this cupola is 3, having each an area of 33 sq. in. These should be flared out double the size at the lining end; the air pressure required is 8 oz. per sq. in. and the velocity of air through the tuyeres 28 ft. per second. The area of cross section of the wind belt should be 3 or 4 times that of the combined area of the tuyeres.

The coke ratio as given is not extravagant, and should be slightly improved. Limestone should be added to the extent of about 25 per cent. The weight of the slag produced should be about 5 per cent. of the weight of metal melted.

DISCE DOSCE.

Casting Copper in "Green Sand."

Copper has been cast by me, but the result has been poor. The outside of the copper casting seemed quite clean and healthy, but after being machined it was seen that the copper castings, especially the flanges, were studded with small holes (not blow-holes), but as if the crystals did not interlock properly. The melting plant is a small natural draught furnace, and plumbago crucibles are used. The foundry where I am apprenticed is very small, employing only two moulders, and it is far from any industrial centre, so I cannot attend any night schools. So could you also advise what books and subjects to study myself in connection with my work.—A. W. H.

Patent Abstracts.

Particulars of Complete Specifications Accepted, furnished by Mr. Eric Potter, Patent Agent, of 27, Chancery Lane, London, W.C.2, and Commerce Chambers, Parliament Street, Nottingham. Printed copies of the specifications in the following list will be on sale on May 29, 1924.

215,046. CASH, J. Means for supporting the moulding-box or pattern-plate of a foundry moulding-machine.

215,095. THERMAL, INDUSTRIAL AND CHEMICAL (T.I.C.) RESEARCH COMPANY, LIMITED, and DUCKHAM, SIR A. M. Removal of matter from the surface of a liquid, particularly in working apparatus for heat treatment by means of molten metal.

215,119. KUEHNRICH, P. R. Production of ingots and other metal castings.

THE MODERN TRANSPORT COMPANY, LIMITED, 25, Castle Street, Liverpool, have removed to Mersey Chambers, Covent Garden, Liverpool.

MR. F. E. W. COLLER, shipyard manager to Sir W. G. Armstrong Whitworth & Company, Limited, has been the recipient of a presentation as a mark of esteem on his retirement from the firm.

THE INDIAN STEEL INDUSTRY PROTECTION BILL has been published. The preamble says the Bill is undertaken in pursuance of the policy of discriminating Protection to provide for the fostering and development of the steel industry by increasing import duties, or granting bounties on certain articles. As recommended by the Tariff Board, the Bill gives the Government of India unfettered power to vary its protective duties with a view to maintaining the effectiveness of the protection against fluctuations.

Dry Sand and Loam Moulding.*

By A. Sutcliffe, M.I.Brit.F.

(*Continued from page* 343.)

MAKING A CONDENSER CASTING IN LOAM.

The making of this casting in loam will first be dealt with. As this was an outside job for an engineering firm, they supplied boards, loose branch and four feet.

After having made a bottom plate and a cope ring (Fig. 3), the moulder can strike the seating for the job from a centre spindle. He must then allow the mould to set overnight. It is then ready for the cope ring, and, having set the four feet, the moulder can build up to the flange bottom of the branch. It is good practice to allow the patternmaker who is in charge of the job to set the branch, the moulder setting the gits on the other side of the branch.

When the branch and gits are in place the mould is ready for bricking up to the joint, having procured building-rings and box-plates for the branch for binding the bottom-part together. For his own purpose the author splits the mould, where shown in Fig. 3, when putting the job together.

For the branch this must be faced with a space of about 3 in. all round for the back plate to fit against. This is shown quite clearly in Fig. 3. It

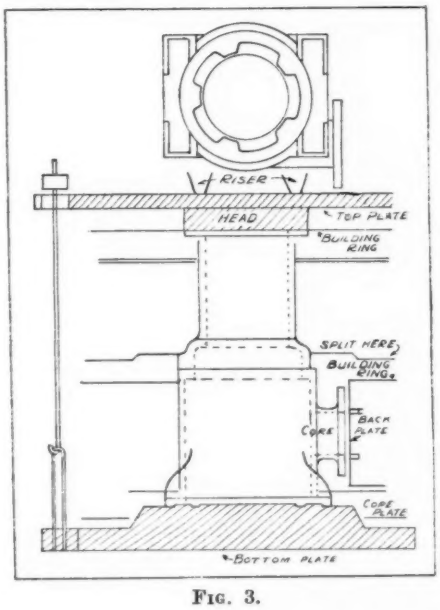

FIG. 3.

will be seen that the first building-ring, just under the first joint, forms the plate for the top side of the flange of the branch, and another for the bottom. This gap can be made a round one, similar to the flange, but, of course, with the necessary bearing; but the author prefers a square one, as it is much better to set and pack, and if this type of job is not well packed and stopped in, the metal will break out.

For the first joint, where the building of the job is split, another lifting ring is required to lift the top portion of the mould away. Having made this ring the night before, it is quite ready for placing on the joint. The board must then be spun round and that all is clear be ascertained. Carrying the over-lapping joint, the moulder is on the straight barrel till he reaches the flange. Here he must not forget he requires 4 in. for the head on the top of the casting. Having placed another building-ring in this top portion, he need have no fear of this casing coming apart when carried about, but if the chain should slip—and this has happened—it would mean making a fresh start.

Now the moulder can make the top-plate, which is prodded as shown in Fig. 3, with two riser holes, a vent hole for the core, and a square prodded-plate for the branch. These plates are daubed with loam, after which they are ready for stoving.

After ascertaining that all joints are marked and that the spindle is out of the way of the casing, the moulder can commence to pull the coping off the seating, leaving the seating still in position. The branch pattern and four feet are removed, and the casing is finished ready for the stove, where it will require to remain for two days.

Next the spindle must be placed back into the socket, the board forming the core is fixed on, after which the moulder can build up what forms the inside of the casting. It must be remembered to keep to size, ascertaining that the five building-in pieces are about half-way up, and that the 4-in. of head has been added to the coping. Additionally 4 ins. must be added to the core.

Two building-in rings will be required for strengthening the core, which will be carried out in the same manner as the cope when the core is built. Now the coping can be brought from the stove, and the seating with the core on returned, remembering the five building-in pieces.

The next job is to finish coping the top plate and the plate for the branch. These three are then returned to the stove for the last time, and the core is brought out, after which it requires finishing, blacking, and returning to the stove to finish drying.

Preparing the Pit.

The method of putting the mould together on the top of the pit and then lifting it into the pit is a bad principle, as when it is lifted with the crane it is liable to be cracked in places, and the metal will get into the cracks and vents, resulting in a bad casting, and, perhaps, someone being seriously burned. The method of putting the mould together in the pit is a much better one—that is, of course, for jobs which require ramming up and not prodded jobs, as the latter are put together and cast on the top.

First the seating with the core is put on in the pit, seeing that this part of the mould is "plumb." The bottom cope must then be put over the core. This cope having been split, the moulder here has the advantage of being able to see all round the bottom.

The gits and branch being complete, the moulder can now fix the core in the branch and put on the covering plate of the flange. This must be well stopped in while the job is warm. The top cope can now be put on to the marks previously made. This being done, the mould is ready for the top plate. It must be ascertained that the core touches this plate and the risers are correct. All the joints can be made up with wet loam, and then the job is ready for bolting up with shackles and bolts—not clamps, as these sometimes "give," and the metal is then liable to run out.

Having made the gits and risers up with waste, the moulder can put the rings around the mould and commence to ram up. At this juncture the moulder must see that the back plate belonging to the branch is well packed, or the metal will escape when it begins to flow. If this method is strictly adhered to there is no reason why this mould should not give a perfect casting.

MAKING A CONDENSER CASTING IN SKIN-DRIED SAND.

This casting, when made by skin drying, is built up in two parts, as shown in Fig. 4. The top part is made from a jobbing pipe-pattern with flanges, one in the socket and the other on the body. Holes are drilled, so obviously it requires very little pattern-making on this half of the job. The other half of the casting—the bottom part—is made by fixing up the core on a barrel, so as to form the inside of the casting; then the thickness is put on the core to form the pattern. The same loose feet and branch patterns are required if made this way.

A hole must now be made in the foundry floor sufficiently large in every way for the job required, but 2 ft. deeper than the face of the mould, as

* A paper read before the Burnley Section of the Institute of British Foundrymen

the branch goes on the bottom. This will allow the cinders to be out of the way. The sand is well rammed on top of the cinders, so that there will be no strain marks when the casting is fetched out.

The pattern-maker having nailed the four feet on the core pattern, the moulder is now ready for this, and it can be put in the hole made in the floor. The pattern must stand halfway above the level of the foundry floor, so it can be carried half away in the top box.

Having the pattern well staked at four corners and well rammed up to the joint, it may now be lifted out and a hole prepared for the branch. This must be set by gauge and staff, as the branch must be in the centre of the two feet and a distance up the body of the casting. The flange on the branch must be covered with a loam cake, which must be well spiked down, or it will lift. If all the holes in the flanges are drilled, the moulder cannot go wrong, as he can drill the holes to suit the centre of the feet and branch.

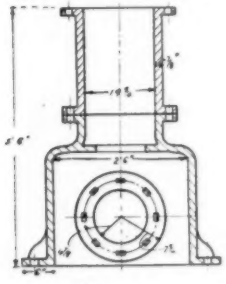

Fig. 4.

Now the moulder can again return the core pattern into the stakes by removing the stakes and making good the holes and the joint. The top box can now be put on. This, taking half the pattern, requires many lifters and a good ramming. This done, the moulder must stake, in four places, and lift off the top box. He must then lift the core pattern out of the mould and take it back into the core-shop. The core-maker is required to take off the thickness of loam which forms the thickness of metal. The core remaining on the boad is blacked, as this is to form the inside of the casting.

Returning to the mould, the moulder can draw out the four feet and branch body, finish, and black the mould with a black wash, the constitution of which is one bucket of plumbago, two buckets of common blacking, one handful of gum, and one gill of core oil. This should be well mixed and allowed to stand overnight.

On the bottom part of the mould the fires are lit and hung over the top box for about one hour. When it is thought to have had sufficient drying, the fires must be taken off. Having placed the top on bricks, the moulder cleans out the cinders, puts in the branch core, then the body core, ascertaining that these two cores touch. After trying on the top box, it is lifted off again, and if everything is satisfactory the top box can be returned for the last time. The barrel is scotched and well stopped in at each end; the gits made up, after which the mould is ready for the metal. The casting is run by sprags on the joint.

Made in this fashion, the job does not require any more pattern-making than it did in loam, but with the latter method it would require plates and tackle, which denote extra cost. A comparison of the moulders' time taken by the two methods is set out below.

Loam.

		Hours.
Moulder	... ...	62
Labourer	... ...	62
Dresser	... ...	5
Weight ...	6 cwt. 0 qtrs. 25 lbs.	

Skin-Dry Sand.

Moulder	... ...	25
Dresser	... ...	6
Weight ...	11 cwt 0 qtrs. 22 lbs.	

MAKING A DYE GIG IN LOAM.

It is probable that the making of this job in loam is unsuitable, taking into consideration time, risk and price. On assuming the management of a foundry, the author found that two castings had to be made off such a pattern, one had been already made and the other one just started. An enquiry as to the time each job had taken, revealed that for the first, for which plates were required, no fewer than 196 hrs. were absorbed. For the second it was reduced to 138 hrs., or 167 for each.

These two were the last cast this way. This casting, the same "over the scales," is now made in dry sand in 54 hrs., and is found to be equally as good, associated with less risk.

The loam job when made from a skeleton pattern, requires the following tackle for the two castings required:—A bottom plate; cope plate; two building plates; plates for core; one building plate; a prodded plate for top of core; and a top plate with 2-in. prods cast on. Seven plates in all. This necessitates about 8 tons of metal being melted, cast and broken up. This is a cost which has to be considered, and there is still required loam bricks and labour to make the mould, which will be in and out of the stove for three or four days.

After putting the job in the pit, with the top and bottom plates bolted together, and with every

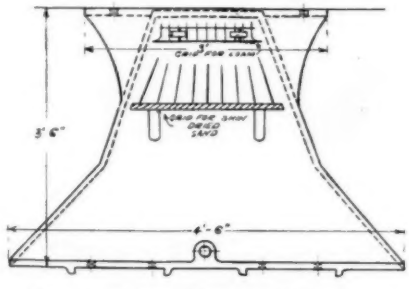

Fig. 5.—When Made in Loam it is Moulded as Shown, but when Made in Dried Sand the Job is Inverted.

joint fastened, it is ready for ramming round with black sand up to the top plate. It will be seen from Fig. 5 that this job cannot be cast on top or in the pit without ramming, as there are no prods on the plates. When this is done, the moulder must make up the gits on the top plate, after which it is ready for casting.

The next job is liberating the casting, by taking out some of the inside bricks. This must be done about one hour after casting.

MAKING A DYE GIG IN SKIN-DRIED SAND.

Making the same job in a skin dried mould, with the same pattern, but with the gaps filled in with plain wood, it will be noticed there is very little difference in the pattern-making.

After digging a hole in the foundry floor large enough to take the job, the moulder first makes a suitable cinder bed, then he levels a sand bed on the cinders. The pattern is then placed downwards on the bed feet, the top of the pattern coming level with the foundry floor. Having made a grid with prods attached, one foot long, it is placed inside the pattern with the prods downwards. The moulder commences to ram up, inside and out, to the top of the grid, having put sufficient packing on the grid to meet the box bars, and bolts to come through the bars for fastening the grid.

The mould is vented down to the cinder bed all round the outside; the gits are placed in at one end—one on both sides the thickness of the metal three inches deep. The up-gits are bushed round all the way up.

Having ironed and rammed up to the top of pattern, the moulder makes the joint and puts on the top box. After this is rammed up, the bolts from the grid are screwed up, the top lifted off, ascertaining that it is well staked three feet above the box. This is most important, as a good guide is required. The moulder can then draw the pattern, finish the mould top and bottom, wet black, and dry with bucket fires. The top is hung over the bottom, and left suspended from the crane over-night.

Next morning the cinders are cleaned out; the top is tried on, paying special attention to the feet and thickness. The gits and the mould are made up weighted, after which it is ready for the metal. After casting the bolts are liberated and the top box removed and the grid taken out.

MAKING A DYE GIG IN GREEN SAND.

It sometimes happens that three different sizes of this casting are being made simultaneously. They are made on the bath principle. In a jobbing foundry, a special box cannot be used for

every job, so each gig is made in the floor, and the mould is skin dried as stated. The making of a dye gig in green sand in a box, however, presents several interesting points.

The bottom part is a full box with two flats, one at each end, about 3 ins. wide. These two flats slide up the end plates of the middle box part in a grove as shown in Fig. 6. The middle box incorporates two end plates and two perforated side plates with bars which reach within ½ in. of the pattern.

The casting is made from a wood pattern with loose boards for the circle top of the pattern. It is moulded by placing the bottom box on the foundry floor—properly levelled—then a 3-in. layer of cinders is put in the bottom box, which is rammed with black sand to the joint of the bottom box. The pattern is placed in position, and the outside joint is dusted with parting-sand. After placing on the middle box, it is part-rammed, whilst at the same time the inside of pattern is also rammed. After reaching the top and after having vented to the cinders in the core, the loose boards that

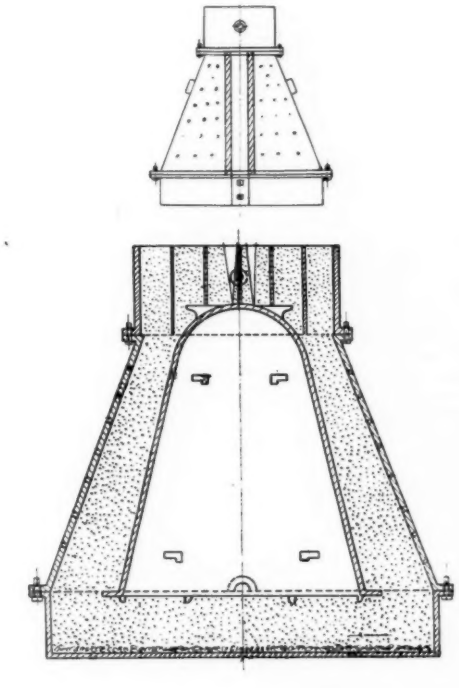

FIG. 6.—SHOWING THE MOULDING OF A CASTING IN A BOX.

form the circle of pattern, is placed on; then the top joint of the middle box is made, dusted with parting-sand, and the top box is put in position, inserting two rows of spikes—six in a row—for gits. The four feet, two at each end, are placed in position, and the top box is rammed up.

The top box, being removed, it is placed on four bricks. The middle box can now be removed, and it must be put on four props to enable the moulder to work on its inside. After replacing the top box on to the middle, it is essential to go inside and make good the joint of the top box and middle, and to see that the gits are all clear, and the four feet are out. Blacking cannot be done at this part of the mould.

Returning to the pattern, the loose boards are taken off the pattern, withdrawn, and the core or bottom part of mould finished. As little slaking as possible is advisable, and it is preferable to dust with a small quantity of best plumbago, as there is only ⅛ in. thickness of metal. The mould is now ready for the top and middle together. It is here where the two flats or guide-pieces guide the box until it reaches the pins in the bottom box. Everything being complete, all that is required now is to cotter up and make up the runners. If this method is strictly followed this should be a good casting.

(To be continued.)

Patent Abstracts.

Particulars of Complete Specifications Accepted, furnished by Mr. Eric Potter, Patent Agent, of 27, Chancery Lane, London, W.C.2., and Commerce Chambers, Parliament Street, Nottingham. Printed copies of the specifications in the following list were on sale on May 15, 1924.

214,307. A. FORD. Foundry moulding machines.

214,402. A. GRAY, Jun., and J. ROBINSON. Coating for moulds such as are used for iron and steel castings.

214,526. J. ROBINSON and A. GRAY, Jun. Composition for moulds for steel castings.

214,532. L. LOMBARDI. Electric furnaces particularly for the melting and the treatment of composite metal and alloys.

205,083. ETABLISSEMENTS, A. SISSON-LEHMANN. Apparatus for the manufacture of foundry moulds.

214,559. I. BINKS AND J. KIDDIER. Extracting ingots from moulds.

Mould Materials; Casting Processes; Moulds; Clamping Moulds.—Relates to the production of self-annealed grey-iron castings in metal moulds and consists in the regulation of (1) the temperature of the iron poured, (2) the temperature of the mould surface, (3) the mould wall thickness, (4) the provision of a refractory lining for the mould, (5) the application to the lining of a thick coating of lampblack, (6) the cleaning of the mould, (7) yielding means for clamping the moulds, (8) the prevention of leakage from the moulds by means of a narrow contact bead or rim, (9) the arrangement of special cooling means in the case of large castings, (10) the composition of the iron cast, (11) the composition of the metal moulds. The moulds are of the same composition as the iron to be cast which has preferably a silicon content greater than 2.75 per cent., a manganese content between 0.4 per cent. and 0.6 per cent., total carbon content between 2.5 per cent. and 3.5 per cent., combined carbon of the pig less than 0.7 per cent., and sulphur, oxygen and phosphorus low. In melting the iron not more than 10 per cent. low carbon steel scrap (0.2 per cent. to 0.3 per cent.) should be added, and the cupola blast is regulated so that the melting zone is confined to a few inches. A mixture of 50 per cent. scrap of composition similar to that set out above and 50 per cent. pig may be used. The moulds may be cast in sand or in permanent moulds and the outer skin may be removed by a small hand grinder. After cleaning the moulds may be heated for an hour to 1,500 deg. Fah. to relieve strains that might result in distortion. A refractory coating is then painted on at a mould temperature of 500 deg. Fah., a suitable composition being a 10 per cent. saturated solution of sodium silicate in water with an equal weight of finely ground fireclay. For complicated castings a less proportion of fireclay is used. When a thick casting is required the mould temperature is raised to above 1,000 deg. Fah., to bake each layer of about 0.01 in. after application. A coating of ¼ in. can be built up in this way. A layer of lampblack is next applied of such thickness that the casting is substantially intact after the casting has been ejected. For castings of 2-lb. weight with sections of from $\frac{3}{16}$ in. to ¾ in. thickness hollow cast-iron moulds of ½ in. wall thickness with a refractory lining of $\frac{1}{16}$ in. thickness and a lampblack coating of $\frac{1}{32}$ in. thickness are employed. A casting is poured every 1½ to 2 minutes and the mould surfaces attain a temperature of 1,000 deg. Fah. The pouring temperature exceeds 2,200 deg. Fah., and the casting is ejected at a temperature of 1,650 deg. Fah. With castings of various sizes the conditions are adjusted to maintain the solidification time in the neighbourhood of 30 seconds, and the frequency of pouring is regulated to keep the face temperature below 1,500 deg. Fah. For large castings the air-cooling means described in Specification 197,334 may be employed. The moulds are mounted on a rotating table and the castings are ejected as described in Specification 186,906, the moulds are cleaned after casting by an air blast as described in Specification 199,390 and the lampblack is reapplied by a burner as described in Specification 204,688. Specifications 201,913, 202,273, and 209,043 also are referred to.

Aluminium-Alloy Pistons.

By F. A. Livermore.

The great change in internal-combustion engines of recent years has been the introduction of aluminium-alloy pistons, its adoption having been the subject of diverse controversy.

At first sight it would seem that the obvious reason for using aluminium-alloy pistons in internal-combustion engines lies in the lightness of the metal and the subsequent saving in weight of the engine. In the case of large and heavy engines this is so, but for smaller engines as used in the automobile trade the thermal effects are of more consequence than the decrease in weight.

Thermal Conductivity.

The effect lies in the fact that aluminium-alloy pistons possess a higher thermal conductivity than iron or steel; iron stands at about 10, while the aluminium piston alloys have a thermal conductivity in the neighbourhood of 40, or nearly four times that of steel or cast iron, so the piston conducts away four times as much heat as the iron.

The advantages of the high thermal conductivity are that the piston works in the combustion chamber at a much lower temperature, a greater compression ratio can be used without risk of pre-ignition, this producing a very marked increase in power, running in some cases up to something like 20 per cent. as compared with the same engine working with steel or iron pistons. Again, because of the high thermal conductivity, carbonisation is decreased and leads to a considerable fuel economy; that is, oil does not carbonise on the underside of the piston head. As a practical feature this is very important, for the carbon so formed collects in the crank-case, fouls the lubricating oil, and only too often chokes the filter and oiling system, with disastrous results.

More Horse Power—less Fuel Consumption.

Dr. A. Gibson, in a series of experiments, found that the aluminium pistons yielded 6 per cent. greater horse-power with 5 per cent. less fuel, and an increase in thermo-dynamic efficiency of 12 per cent.: the inertia forces are reduced to such an extent that vibration is practically eliminated, and much higher speed can be obtained.

In considering the adoption of aluminium alloys for pistons, one is faced with a series of difficulties which must be satisfied by the metal: (1) The strength of the material must be such that it will resist shocks such as occur in internal-combustion engines, especially momentary increments of pressure arising from pre-ignition. (2) The material must have a high thermal conductivity, since the heat is intermittently applied only to the head of the piston. (3) The co-efficient of thermal expansion must be comparable with iron, otherwise the increase in clearance to compensate for a greater co-efficient of expansion would cause piston slap, until the engine warmed up. (4) The alloy must be capable of resisting the wear of the piston rings. (5) The alloy must be readily compounded and worked.

Influence of Temperature.

Most alloys of aluminium decrease in tensile strength proportionately with rise in temperature. Consequently, in considering the adoption of a particular alloy, the ultimate strength at temperatures between 200 and 400 deg. C., subject to such alternating stresses as would occur in the cylinder, must be ascertained. Take an alloy containing 13 per cent. of zinc and 2.5 per cent. of copper. At ordinary temperatures the tensile strength is 6.8 tons per sq. in., but falls at 250 deg. C. to as low as 2.1 tons per sq. in. This alloy, like all those containing any proportion of zinc, is entirely unsuitable for piston work. Large numbers of pistons were made during the war from an alloy containing 12 per cent. of copper; at ordinary temperatures the alloy gives a tensile of about 10 tons per sq. in., but at 250 deg. C. the figure has fallen to less than 3.5 tons. Investigations into the preparation of alloys to satisfy the tensile required at high temperatures soon led to the improvement of the alloys. One per cent. of magnesium was added to the 14 per cent. copper alloy, and it was found that at ordinary temperatures the tensile was 4.5 tons per sq. in., which when heated to 250 deg. C. the tensile was 5 tons per sq. in. Unfortunately this alloy was rather heavy, due to the high copper content, and the effect of replacing some of the copper by nickel was studied. Numerous tests have been carried out with this alloy, and finally the following alloy was advocated as extremely good for piston work.

It contains:—Copper, 4.0; nickel, 2.0; magnesium, 1.5 per cent., aluminium remainder. The tensile strength of a chill cast bar is about 7 tons per sq. in., and at 250 deg. C. will maintain a strength of nearly 9 tons per sq. in.

"Y" Alloy.

The National Physical Laboratory advocate the suitability for piston work of an alloy containing: copper, 4.0; nickel, 2.0; manganese, 1.5 per cent., and aluminium remainder. This in the form of 1-in. test bars—chill cast—gives an ultimate stress at 250 deg. C. of approximately 12 tons per sq. in., compared with 6 tons for a 12 per cent. copper alloy.

Recently, by special heat-treatment, the strength of these last two alloys has been increased to a marked degree; the pistons are subjected to a temperature of about 380 deg. C. for at least 6 hrs.—it is preferable to prolong this annealing to one day—in order to bring the copper-aluminium eutectic ($CuAl_2$) in the alloy into solid solution.

The thermal conductivity of these alloys is particularly favourable, and, in addition, the specific heat is very high; these two properties together cause aluminium pistons to become far less heated in use than cast-iron pistons. The actual piston temperature reached is generally lower than that of the decomposition of the lubricating oils, so that carbonaceous deposits as form on iron and steel pistons do not form on aluminium pistons.

Thermal Expansion.

The thermal expansion of aluminium alloys is very much greater than that of iron and steel; the actual comparison is 25 in the case of aluminium alloys, as compared with 10 in the case of steel. This implies the necessity for a considerably greater amount of clearance between the pistons and the cylinder when cold. Too much clearance will give rise to piston slap; on the other hand, too little clearance will cause seizure, with disastrous results. J. Hacking, in a Paper read before the Institution of Automobile Engineers, stated the following as the best clearances:—"Taking 'D' as the cylinder bore, the clearance of the skirt should be from 0.0015D to 0.0010D, and for the head 0.0025D. As a basis of comparison the figures for cast-iron pistons average 0.0006D for the skirt and 0.0015D for the head." For air-cooled cylinders, naturally the clearance would be much greater, and the figures most compatible with efficiency in piston slap adapted.

The vertical clearance and wear of the piston rings on the grooves into which they fit require special attention, and the clearance should be kept as small as possible in order to obtain good compression.

Burning of Aluminium Pistons.

Although on the whole aluminium pistons are proving eminently successful in all types of internal-combustion engines (both water, oil, and air-cooled), a certain amount of trouble has been experienced with them in practice. In cases, the upper side of the piston head shows it to be pitted similar to a sand-eaten casting, and no doubt the cause from the practical standpoint has been either the failure of the lubrication system with partial

local heating, or through a badly-designed piston. From the metallurgical standpoint, the failure appears to be due to the fusion and migration of the copper-aluminium eutectic, with the ultimate disintegration of the whole metal. It is necessary when casting piston alloys to keep the temperature as low as possible, to avoid the existence of large connected masses of the aluminium-copper compound.

Piston Design.

The piston—no matter in what engine it is incorporated—functions as the agent for producing mechanical energy from heat. But, at the same time, it must allow the escape of excess heat during the conversion of heat to work, otherwise the engine will show signs of such undesirable qualities as pre-ignition, excessive expansion on the skirt, etc., and because aluminium has satisfied these requirements, it has gradually superseded cast-iron and steel. The piston should have a good body of metal in the head: experiments show that the thickness should be about 7 per cent. of the piston diameter, but the thickness must increase from the centre to the wall, so that the temperature gradient is kept at the maximum. A good body of metal should be left behind the piston rings; this ensures adequate cooling through the skirt of the piston, and hence to the cylinder walls.

The actual length of the piston should be equal to its diameter. A good deal has been said and written on the supposed "growth" of aluminium alloys when heated and cooled alternately, and it is said that the piston may be very slightly distorted, probably due to the release of casting strains. Measurements of this growth have been made, and the results show that it is practically negligible in comparison with the thermal expansion. In any case, if the piston castings are annealed well before use, there is little fear of this difficulty. The heat-treatment gives best results at a temperature of about 380 deg. C. for at least six hours.

It is interesting to note that wrought aluminium alloys are being used for connecting rods, which, as is known, are exposed to very severe alternating stresses, and at the same time, at all events, they are exposed to a high temperature. The alloy best suited for this purpose is the "Y" alloy specified. By the use of such rods, not only is it possible to still reduce the weight of reciprocating and rotating parts, and so raise the engine to a higher mechanical efficiency, but the high thermal conductivity proves of great importance by accelerating the dissipation of heat from the connecting rod big-end bearing.

An experimental rod made from an alloy of practically the same composition as given above, and machined to the usual mild-steel connecting-rod dimensions, was fitted to a small internal-combustion engine, and was constantly used for over twelve months. It was subjected to a gruelsome test, but showed not the slightest sign of rough treatment; the connecting-rod bearings of white metal were exceptionally good.

Research in the Wembley Palace of Engineering.

Of interest, alike to the technical engineer and to the layman, will be the display of scientific testing and measuring apparatus and methods which the National Physical Laboratory is making in the shipbuilding, mechanical and general section of the British Empire Exhibition.

The display will cover 1,500 sq. ft. of floor space, donated by the organisers of the section—the British Engineers' Association—in the interests of the industry, and will demonstrate effectively the accomplishments and indispensability of this national institution which, founded in 1899, is to-day perhaps the greatest research organisation of the world.

Five of the Laboratory's eight departments will be represented, viz.: Physics, Metrology, Engineering, Metallurgy, and the William Froude National Tank. The Physics Department will show in operation one of the latest type electric furnace, with its high temperature pyrometer, and will conduct X-ray examinations into industrial materials in search for faulty workmanship and to illustrate the atomic structure of pure metals, alloys, and compounds. Hygrometers of various types for investigating humidities will be displayed, together with a special arc furnace used for highly important research work on arcs at high pressure.

The engineering department presents machines for testing the strength and efficiency of chains, gears and bearings, and a Wöhler fatigue testing machine, which, aided by a small mirror, indicates when a metal has reached the limit of its endurance. Examples of castings, wrought alloys, test pieces, forgings, and special alloys are shown to illustrate the effects of heat treatment and their resistance to fatigue; investigatory methods are described and typical failures shown in the metallurgy department, which also includes many interesting photographs of plant and apparatus and specimens demonstrating the behaviour of mild steel under cutting tools. Electric furnace controls are displayed in operation.

A wax model of a ship as employed for tests draws attention to the William Froude National Tank, which predicts the resistance of given forms of ships, the power necessary to propel them, and any other of their qualities on which information is desired. Such models as that exhibited are towed at a speed corresponding to that of the actual ship across a large tank by an electrically-driven travelling carriage, during which run all the required measurements are taken.

Altogether the exhibit of the National Physical Laboratory will be a striking demonstration of the amount of research and mathematical precision which lies behind the finished products of the British engineering industry, and which is, to some extent, responsible for the reputation our manufacturers enjoy for the quality of their goods.

Copper-Zinc Alloys which Expand on Solidification.*

By Kei Iokibe, M.Sc.

Summary.

1. The marked expansions observed by Turner and Murray in slowly cooled alloys containing about 85 per cent. zinc and 15 per cent. copper are confirmed.

2. The amount of this expansion depends upon the percentage of copper and the rate of cooling.

3. The force of expansion of these alloys is of considerable magnitude.

4. The hardness and elastic limit of the expanded alloys are low, and they contain cracks and voids.

5. The expanded alloys show considerable uniformity in chemical composition throughout the length and diameter of a cast bar.

6. The density of turnings from the expanded alloys, or of compressed cylinders, is greater than that of the casting, and may exceed that of the theoretical (no change of volume) curve. Higher density values are also obtained by weighing after evacuating.

7. In quickly cooled (chill-cast) bars the density varies along the length, and more particularly across the diameter of the bar. The copper content is higher, while the density is lower, in the centre of the bar.

8. The effect of this "inverse segregation" can be diminished by subsequent annealing.

9. This "inverse segregation" in the chill-cast bars is proportional to the expansions in sand-cast bars; it has the same range, and the same maximum of copper content.

10. The expansions are most marked where the solidifying range is greatest. There is no thermal indication of the solidus line in this region, but it has been determined by Imai, using the electrical conductivity method.

11. Observations are submitted on the cause of "inverse segregation."

* A Paper presented to the Spring Meeting of the Institute of Metals.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Low Temperature Reduction of Iron Ore.

To the Editor of The Foundry Trade Journal.

Sir,—In your issue of April 3 you published an article by Mr. J. Kent Smith, O.B.E., which suggests the practicability of low temperature reduction of iron ore on a commercial scale and concludes: "It may confidently be prophesied that the next ten years will see a very general adoption of the commercial reduction of iron from its ores at low temperature."

Not without honouring the confident prophet of a return to the times when iron was reduced at low temperatures, we can at least scrutinise the statement that such a return will be made within the next ten years. Apart from theoretical considerations of the metallurgical aspects, the usurpation of the position held by the modern blast furnace seems remote. Though it may be pointed out that according to the simplest formula for the reduction of pure ferric oxide by pure carbon, ignoring the effect of reversible reactions, only 4.84 cwts. of carbon are necessary to make a ton of iron, and that a modern blast furnace with a 50 per cent. ore uses, say, 18 to 20 cwts. of coke per ton of pig, there appears some justification for a charge against the blast furnace of thermal inefficiency, even with the allowance of over 4 cwts. of coke which provides motive power by means of the surplus gases.

A graver charge of the same nature can rightly be levelled against prime movers, but no confident prophet has appeared in this connection. The best lines of advance in both cases seem to be made in perfecting the existing appliances. In any case, a radical alteration of existing methods takes usually more than ten years to become commercially safe.

Consider the difficulties before the arrival of the blast furnace. It was stated that 1,500 lbs. of low-grade fuel were required for the low temperature process, against 2,000 lbs. of coke for the blast furnace. The difference in cost at to-day's prices in the author's district is (say) 13s., on the face of it a comparatively large amount compared with the selling price of the semi-finished product, but a sum that is soon frittered away in extra labour charges, repairs and maintenance, works, general and capital charges, depreciation, in small increases in "off" grades, and in providing motive powers.

By deducting the present prices of ore from the selling price of the pig-iron, it is found to-day that in different parts of this country there is a sum of from 50s. to 70s. depending on the iron ore used, available to meet all these charges, plus the cost of all other raw materials used, plus profits. It is extraordinarily small, and any process, low temperature or otherwise, will need very skilful planning and operation to improve upon it. In detail, is a lower labour cost suggested than 3s. to 3s. 6d. per ton, the approximate figure for a good blast-furnace plant in this country to-day, or a bill for repairs and maintenance of 2s. 6d.?

Even comparatively lower-priced commercial products such as coke or cement are, on a comparative basis, not less expensive to produce as far as these items are concerned. Depreciation, too, of 1s. 6d. per ton, a figure on the high side for blast furnaces, will only with difficulty be improved upon. Until specific examples are forthcoming, or specific references to such commercial considerations be made, a reasonable scepticism will be felt of advantages claimed for the economic employment of radically altered methods.

But apart from commercial considerations, difficulties will arise on account of the impurities always associated with iron ore. Sulphides, silicides and phosphides of iron exist at low temperatures, and hence no advantages of a reduction of these impurities to any marked extent can be claimed. It is anticipated that the present difficulties on account of the presence of sulphur will be enhanced. Indeed, no claim was put forward of improvements in the deleterious impurity content, and until further information is forthcoming of the control of these elements, it seems improbable that a large proportion of ores in use at present will not be available for the suggested process. The statement as to a low-temperature reduction auxiliary plant being used for dead fine ore is invalidated on this account. Sintering, on the other hand, is a proved theoretical and commercial success.

In spite of the author's remarks as to the increase of our knowledge of the utilisation of powdered fuel, essentially low-grade and of irregular chemical analysis, it is doubtful whether our knowledge is sufficiently extensive to enable this material to be used as a reducing agent reasonably definite and regular in its chemical action. As a source of heat only, it is well-known that electric furnaces, producer-fired open-hearths or kilns, externally-heated retorts, even with the most effective regenerative appliances, are very much more wasteful of heat than blast furnaces. In any case, a blast furnace *is* a low-temperature reducing appliance as far as its shaft is concerned, as Johnson took some pains to emphasise.

To summarise briefly, the advantages to be expected are the gain in using low-grade fuel (which, incidentally, will respond in price to any increased demand) and a gain due to the smaller amount of heat required represented by the difference between the melting temperature and the low-temperature reduction point. The disadvantages are less control and the use of more inefficient apparatus. The question of capital outlay, which is stated to be smaller, was probably not referred to an equivalent output basis. Taking into consideration the nature of the raw material worked upon, and the bare essential efforts that have to be made in producing the semi-finished product, the margin for a reduction in costs is so remarkably low (and it may be said, in passing, that the margin would be lower in this country if plants were more generally up to date) as to make the credibility of economies doubtful without the fullest investigation into the practical working for a reasonably long period.

Though obviously no manufacturing process can be stated to have reached its final development, it is well to realise, as accurately as possible, the obstacles that have to be surmounted, and the extent to which a suggested process is able to compete with present conditions, before any new departure is made, involving expenditure of capital that could more usefully be employed along safer lines, in particular the remodelling of existing blast-furnace plants.

Yours, etc.,

Richard Miles (Major).

Carr House, Chapeltown, Sheffield.
May 12.

Iron and Steel Output in April.

The National Federation of Iron and Steel Manufacturers report that the production of pig-iron in April amounted to 618,400 tons, compared with 668,600 tons in March and 652,200 tons in April, 1923. The production in April included 188,400 tons of hematite, 221,400 tons of basic, 145,800 tons of foundry, and 33,700 tons of forge pig-iron.

The output of steel ingots and castings in April amounted to 711,500 tons, a decrease of 105,400 tons compared with March, and a decrease also compared with April, 1923, when the output amounted to 749,400 tons.

Greenly's, Limited, the well-known advertising agents, have removed to larger premises at 5, Chancery Lane, W.C.2.

Mr. Hugo Hirst, chairman of the General Electric Company, Limited, speaking at the Wembley Exhibition, following on an inspection of the numerous exhibits of the company, said that while one could imagine an exhibition of pictures or jewellery being praised by visitors, an engineering exhibition, he thought, left them cold. It created no warmth. "We can only show the things that do the service," he said, "we cannot show the service," and he pictured the utility of electricity from its aid in the hospital and at home to its regulation of the temperature in the stokehold of the ship at sea, and especially how in the refrigerator it was the basis of cheap food. He looked with misgiving on the removal of the McKenna duties at a time when new industries needed help.

Cast Iron in Motor Car Construction.*

By F. H. Hurren, A.I.C., M.I.Brit.F.

The value of any class of material is measured by the importance of the uses to which it is subjected, and in motor car construction the importance of cast iron cannot be over-estimated. This will be readily understood when it is realised that the cylinder, on which, to a large degree, depends the active life of the car, is made in that most complex of all materials, cast iron. The extent to which the cylinder stands up to its work, retains its shape under alternate heat and cold, resists abrasion, vibration, and in many instances unexpected stresses due to bad driving borders on the miraculous. There should be included in this tribute to the efficiency of cast iron the pistons, piston rings and valve guides.

Sometimes the cylinder and head are cast in one piece; modern automobile practice is to make separate castings of the cylinder head and cylinder body. In a few cases the top half of the crankcase is incorporated in the cylinder body casting.

High efficiency engines of small capacity often run at over 4,000 revolutions per minute, whilst large capacity engines for touring cars have a normal speed varying from 1,400 to 2,500 revolutions per minute. When these figures are calculated out as piston travel, it seems wonderful that an engine will last even a few hours, let alone the years of service and many thousands of miles that most cars accomplish. With an engine of 5-in. stroke a speed of 2,500 revolutions per min. incurs a piston travel of nearly 700 yards per min., or 24 miles per hour. When this is kept up for hours at a time the pistons and cylinder walls must have a high resistance to friction, or undue wear will result.

Other parts of a motor car, where cast iron is utilised, are the flywheel, clutch plate, clutch cover, exhaust branch, certain chain wheels on the timing gear, brake shoes, liners for brake drums, bearing carriers, and small distance pieces and cover plates. To attempt to use one class of iron for all these parts would be courting disaster. For instance, the material in the flywheel must be such as will resist any tendency to disintegration due to centrifugal force. The clutch plate must have a high resistance to friction, and yet not so harsh as to cause a fierce action. The clutch cover must be proof against porosity, otherwise oil will leak, which, in addition to uncleanliness, will ultimately give rise to over-heating of the clutch mechanism. The exhaust branch must be non-porous, and free from any tendency to grow under repeated heatings. Chain wheels must resist abrasion, or the timing gear will soon become noisy. Brake shoes are usually covered with a fabric, such as Ferodo, but must be strong to resist distortion. Liners for brake drums must have a high coefficient of friction, whilst the wear due to abrasion must be slight. Bearing carriers have no great stresses imposed on them other than those due to constant heating up and cooling down again. When distance pieces are made in cast iron compression strength is necessary. Finally, there is cast iron used as cover plates, and here no definite stresses are set up.

Cast iron has the advantage of being comparatively cheap, and in many instances the cost of producing a casting is considerably greater than the value of the material put into it.

The principles underlying the moulding of cast iron are much the same whatever the type of casting, but to those who are not familiar with the production of automobile cylinders the delicate and intricate nature of the cores is a revelation. A cylinder head made in the Rover foundry some time ago had 31 separate cores, most of them very intricate, yet the casting only weighed 43 lbs. when completed. It is their practice to cast all cylinders in dry sand moulds, and other parts in green sand. The cylinder moulds are rammed up and blacked, dried in the stove during the night, then cored and cast the following day. Where the quantity warrants the initial expense, the ramming up is done on jolt machines from iron patterns. In the case of air-cooled cylinders a brass pattern and stripping plate is used on a jar-ram machine. It is not proposed to deal with details of moulding practice, but to consider the technical and metallurgical aspects of the production of automobile parts, and the extent to which science can assist.

Melting Aspects.

The type of furnace almost universally used for melting cast iron is the cupola, which, although it has no peer as to low cost of production and flexibility of output, is subject to certain serious disadvantages. There is always an increase in the sulphur-content of the iron after melting; and unless the cupola practice is closely controlled grave irregularities in composition are possible. A quite recent development is the refining in an electric furnace of molten iron from the cupola, but the author has had no practical experience of this process at present.

Entrance of Sulphur.

The metallurgical functions of the cupola are fairly well defined, and a certain weight of cast iron requires a definite number of B.Th.U. to melt it and give it the correct degree of superheat. These B.Th.U.s are obtained by the combustion of coke in a defined volume of air, and herein lies one of the many difficulties. Coke, as supplied to the foundries, is a very variable item. A good cupola coke should contain at least 88 per cent. fixed carbon, not more than 10 per cent. ash and 0.8 per cent. sulphur. The reason iron gains in sulphur is easily seen. On an average it requires 100 lbs. coke to melt 700 lbs. iron. That 100 lbs. coke, on a normal analysis, contains 0.8 lb. sulphur. Assuming that only 25 per cent. of the total sulphur is absorbed by the iron, and the remainder either passes into the slag or is volatilised off with the chimney gases, it follows that 0.2 lb. sulphur is absorbed by 700 lbs. iron, giving an increase of 0.03 per cent. in the sulphur content of the iron. As it is quite possible that a higher percentage of the available sulphur is absorbed, and a coke with a sulphur content as low as 0.8 per cent. is an exceptionally good quality, it is within the bounds of ordinary practice to charge into the cupola an iron with an average of 0.08 per cent. sulphur, and tap out iron containing 0.15 per cent. sulphur. In addition to variations in composition, coke varies considerably in physical properties. It should be hard and strongly resistant to crushing, otherwise the weight of the various charges in the cupola will tend to powder the coke, with the result that melting will be slow and the metal not sufficiently superheated. The coke should be fairly porous, as if too close-grained it will not burn freely and evenly.

Pressure and Volume of Air.

The pressure and volume of air supplied to the cupola is an important item, volume being equally as important as pressure. If the pressure is high, uneven melting will result, and the metal in the centre portion of the cupola will melt before that at the sides. If the pressure is too low, the sides only will melt, and unmelted pig and scrap will descend in the centre.

If the volume of air supplied is insufficient, melting will be slow and the metal cold. If the volume of air is much greater than that necessary for the complete combustion of the coke in the melting zone, the iron will melt rapidly and hot, but a danger of oxidation is present. In connection with this point there is considerable diversity of opinion, some authorities stating that the presence of oxide in iron is a myth.

Tuyeres.

The shape and area of the tuyeres have an important bearing on melting, and the area of the tuyeres should bear a definite relation to the cross-section area of the cupola. It is generally accepted that the total tuyere area should be from one-fifth

* A Paper presented to the East Midlands Branch of the Institute of British Foundrymen, Mr. S. H. Russell presiding.

to one-eighth of the cross-section area of the cupola, the larger tuyere area being for small cupolas, and the ratio decreasing as the diameter of the cupola increases.

Bed Coke.

It is usually laid down in practice that the bed coke should extend from 18 in. to 24 in. above the top tuyeres. If in any doubt as to the correct height, the safest course to adopt is to take the time which elapses after putting on the wind for metal actually to flow from the tap hole. This time should be not less than 8 min. nor more than 12 min., but it is necessary to be sure that the bed coke had burned through before blowing commenced. The amount of coke on the bed should be adjusted until the first metal melts within these times.

Weight of Iron Charges.

An important item is the weight of iron per charge, and the ratio between the weights of iron and coke per charge. It is obvious that the weights are governed by the internal diameter of the furnace. It has been demonstrated that, when the cupola is working to the best advantage, the bed coke is reduced in depth from 4 in. to 5 in. for each charge of iron, and this loss of coke has to be replaced each time a fresh charge of iron is fed into the furnace. The practice the Rover Company usually adopt is first to find the weight of coke required to fill a space equivalent to the inside diameter of the cupola by 5 in. deep, and use this amount of coke between each charge of iron. The weight of iron per charge can now be calculated, bearing in mind the type of iron to be melted, the size of the pigs, and the amount of superheat required. For cylinder work the author takes this weight as seven times the weight of the coke charge. Translated into definite figures, on one cupola 1¼ cwt. of coke is used for every 8 cwt. of iron.

Patching the Cupola.

It is necessary each day to patch up the cupola lining with ganister after chipping off excrescences of iron and slag. This patching must be done with care and discretion, or the ganister is liable to flake off and impede the melting.

Coke, Flux and Iron.

Attention must be given to the method of charging coke, flux, and iron. The flux most commonly used is limestone, and the author prefers to charge this on top of the coke, though some charge on top of the iron. The amount of limestone used must bear some relation to the ash content of the coke, and the amount of sand adhering to the pig and scrap in the charge. The slag formed has a decided effect on the physical properties of the iron when melted, and should have a refining influence.

The rate at which the metal is tapped out is important, and it should be the aim of the cupolaman to time his tapping out to coincide with the complete melting of a charge.

There are many difficulties in the way of getting good melting results, but it must not be imagined that these difficulties are insuperable. The large number of cupolas in daily use, with good results, negative this idea, but watchfulness, care, and an intelligent appreciation of the metallurgical processes involved are very necessary to obtain hot, clean iron. The melting of iron in the cupola is not the simple operation it appears to the casual observer. At present no other system can compare with it on a basis of cost of output, and until some other method, equally as cheap and flexible, but more fool-proof, is devised, despite its drawbacks, the cupola will remain the universal melting unit for cast iron.

Testing Cast Iron.

In the testing of cast iron the usual tests specified are transverse or tensile test. Useful as such tests may be for some purposes, they are of no practical value in an automobile foundry. Neither transverse nor tensile test give any indication of the probable life of a cylinder, nor, for that matter, of any other casting. At the very utmost they only give an indication of the class of iron used. The tensile strength of cast iron is a function of the size of the test piece. A bar ¼ in. dia. tested "as-cast" will give a totally different result from a bar 1½ in. dia. cast from the same shank. A transverse bar, cast square or rectangular, will give a result differing from that of a round bar. Whether "cast-on" or cast separately, the author considers test bars are of no practical value in motor-cylinder work. A high tensile or tranverse test will not ensure a long-life cylinder. For certain automobile parts an impact test might be of some practical utility, but this test has not yet been properly developed in connection with cast iron. The Frémont test, recommended at the Birmingham Convention by M. Ronceray, suffers from the same disabilities as the transverse and tensile tests, in that it only indicates the class of iron of which the casting is composed.

The mechanical test which can be most usefully applied to motor cylinders is the Brinell hardness test; and this has its limitations. Used spasmodically it is valueless, but used regularly on the same type of casting it will give some indication of the useful life of that casting. That is to say, when one particular cylinder pattern is regularly produced, as a repetition job, if the Brinell hardness is taken daily on a certain section of that cylinder, the readings so obtained will be of value in determining whether the casting will conform to the standard which has been adopted. This standard can only be decided upon after a lengthy practical experience of the particular casting under review. To elaborate this, the Rover Company has found that if the Brinell hardness taken on a certain area of their 14-h.p. cylinder is less than 175, undue wear is likely to take place. The figure sought for lies between 200 and 220. They have also found by experience that if the Brinell No. is over 240, difficulties are encountered in machining. The author has listened at different times to much adverse criticism of the Brinell test, but he is convinced that, used consistently and intelligently on repetition production, it is of some considerable service. It has the advantage of being cheap, does not spoil the casting, and results are quickly arrived at. Hence the author's practice is to cast on all cylinders a small test piece of standardised dimensions, which is rammed up and dried as an integral part of the mould. On the morning following casting, these test pieces are knocked off, and a number of them tested to see if they come within the range of Brinell numbers we have adopted as standard. Any serious discrepancy can be immediately investigated, and if necessary, an alteration made in the iron mixture.

Chemical Analyses.

TABLE I.—*Analyses of Cast Iron Taken from Three Different Parts of the Same Cylinder.*

	Foot. Per Cent.	Barrel. Per Cent.	Jacket. Per cent.
T.C.	3.53	3.58	3.52
C.C.	0.73	0.83	0.90
Gr.	2.80	2.75	2.62
Si.	1.34	1.36	1.38
S.	0.12	0.12	0.12
P.	0.59	0.58	0.59
Mn.	0.71	0.75	0.77

The Rover Company regularly takes analyses of the cylinder iron, and if properly interpreted, these afford a certain amount of useful information. The composition of cast iron for cylinders is a very open question, and with our present knowledge it is folly to dogmatise. It is possible for two irons to have practically identical analyses yet totally different properties.

Most engineers demand a hard surface in the bore of the cylinder. To the author's mind this is quite a mistake. The bore is usually the thickest section of a cylinder, and hence is softer than the water jackets and valve ports. Reverting to Brinell hardness, although the test piece may give a reading of 210, the bore may be only 150 or 160. To obtain a hard metal in the bore, it will be found that the water jackets, valve ports and seatings will be much harder, and often border on white iron. To overcome this trouble some founders use a soft iron and chill the bores. The use of chills in cast iron is always to be deprecated, as they often cause trouble from blowing and mis-placement. That there is not a very great difference in the analysis of the iron in different parts of the same cylinder is illustrated

in Table I. This gives the analysis of the iron from the thick foot, from the barrel, and from the thinnest section of the water jacket. These figures are typical of many tests. As might be expected, the only difference is in the combined carbon and graphite content.

If the functions of a cylinder bore are carefully considered, it will be recognised that it is a bearing, and as such should not be glass hard. To operate as a bearing, the material should be soft but tough, if toughness may be admitted as a property of cast iron. Too often wear on a cylinder bore is due to incorrect piston-ring design, or inefficient lubrication, and to remedy a defect in design harder cylinder bores are called for. The physical form and distribution of the graphite mainly determines the life of a cylinder. It is not suggested that any soft iron is suitable for cylinder bores. An ideal material for cylinder castings would probably be one containing a high total carbon and low phosphorus. A total carbon of 3.6 per cent., with a phosphorus content of less than 0.2 per cent., undoubtedly will give a long-life cylinder, whether of the water-cooled or air-cooled type. There are certain difficulties in the way of casting, and a considerable degree of superheat in melting is essential, but once these difficulties are overcome, excellent results in use are possible. For an air-cooled cylinder to give the best results in use a very low-phosphorus content is most desirable. Phosphorus promotes fluidity, which is essential for casting air-cooled cylinders in order that the thin radiator fins will run up sharply: but the same or a greater degree of fluidity is possible with a low-phosphorus iron, provided the right amount of superheat is obtained.

Composition of Automobile Cylinders.

The correct composition for an automobile cylinder is a very debatable point, and considerable research work remains to be done. Such an investigation, if carried out by one of the recognised research associations, would yield information of prime importance to the automobile foundry trade.

The cooling curves of cast iron vary with different compositions. Recently Smalley has shown that on a Diesel engine cylinder iron, solidification commences at approximately 1,240 deg. C. and is complete at 1,160 deg. C., whereas with a locomotive cylinder iron solidification commences at 1,231 deg. C. and continues to 935 deg. C. The freezing range of the former is 80 deg. C., and of the latter 296 deg. C. In cylinder work it is eminently desirable to use those irons which have the shortest cooling range, otherwise parts of the casting are a long time in setting, during which time certain constituents are thrown out of solution with the formation of dirty patches and sponginess.

In deciding on mixtures for cylinder castings, many factors have to be taken into consideration. The amount of total carbon, the relation between the graphite and combined carbon contents, the form in which the graphite is present in the casting, the phosphorus and silicon content, and in a less degree of importance, the percentage of sulphur and manganese, all demand attention.

In connection with the composition of cylinder iron, the author had the opportunity, some time ago, of making an analysis of a cylinder iron which had been cast in 1840. Needless to say, this was not an automobile cylinder. The total carbon was 3.52 per cent., with a combined carbon of 0.70 per cent. Silicon was 2.15 per cent., sulphur only 0.02 per cent., and both the phosphorus and manganese were fairly high, being 1.18 and 1.11 respectively. This cylinder had been in regular daily work for 71 years.

The Rover foundry has been casting cylinders since 1906. During that time they have had opportunities of seeing how certain cylinder castings stand up to their work, and their length of service. Even now, after 18 years' experience of automobile foundry trade, the author is unable to offer any particular composition as being definitely the best. The Company has varied the composition from time to time, in addition to the small variations which naturally occur from week to week.

No definite limits in the constituents can be laid down, but that success depends on the balance of the constituents one with the other, in order that the cooling range may be short. Probably if the phosphorus content is low it is an advantage to have the total carbon high. With a high phosphorus content (and many of the special brands of iron sold for cylinder work contain up to 1.4 per cent. phosphorus), a low total carbon is preferable. This must only be taken as an expression of opinion. Considerable importance is attached to the sulphur content, and almost certainly this element has too often been given undue prominence. The author has failed to find any detrimental effect with sulphur up to 0.14 per cent., but above this amount there is an increasing tendency to form gas holes under the skin, causing the casting to be rejected after machining. As previously mentioned, sulphur in cast iron is increased by cupola melting; until there is a better alternative to the cupola, sulphur will continue to be a certain amount of trouble.

The casting of cylinders is a very troublesome job, and care in every operation of moulding, core-making, melting, and pouring is essential to obtain good results. However suitable the composition of the metal may be, carelessness in production will only result in defective castings.

Cylinder-head castings, whilst not always so intricate as cylinder bodies, demand the same attention to detail. The tendency of modern design is now in the direction of fairly simple cylinder body castings, and exceedingly complicated head castings. This applies more particularly to engines with overhead valves. Some of the cylinder-head patterns received during the past few months have been veritable works of art. Foundry work in connection with the motor trade is becoming more and more difficult, and the time is ripe for that close co-operation with the designer desired by the modern foundryman

After fettling and sand-blasting, cylinder castings are tested in the rough for freedom from porosity. This operation is usually carried out on a small hydraulic pump at 50-lbs. pressure. Any indications of leakage are carefully examined. If the leak is very slight, the pressure is maintained for some minutes, the casting removed, allowed to stand for several days, and again tested. In many instances all signs of leakage will disappear. Castings which pass this test are sent into the machine shop, where, after being finished-machined, they are again tested at 50-lbs. water pressure. Cylinder castings after machining must be entirely free from blowholes, porous patches, or marks of any description in the bores, on valve-seats, and on joint-faces. The water spaces must be cleared from sand and wires, and "flash" between the joints of the cores eliminated. This latter is often an awkward job to complete in the rough casting, and may, with advantage, be finished after the casting is machined. The core holes and water connections are usually larger after machining, and it is easier to get a tool inside to knock out any "flash."

Pistons and Piston Rings.

The castings which rank next in importance to cylinders are the pistons and piston rings. To some extent aluminium is displacing cast iron for pistons: any reduction in weight of reciprocating parts being very desirable. At the same time, quite a large number of cars on the road have cast-iron pistons giving every satisfaction. It is the practice of the Rover concern to cast pistons in the same class of iron as cylinders. A piston does not require to be hard, otherwise there is always the risk of cracking. The difference in temperature between the head and skirt during the running of the engine is fairly considerable, and although there is not quite the same action as in Diesel engines, a fairly low phosphorus iron is to be preferred. As a rule, pistons do not present any serious difficulties in casting, and the permissible range of composition is wide. The castings are generally tested after machining for porosity with paraffin and oil: in addition there are the usual shop tests for weight, balance, and concentricity.

The manufacture of piston rings is rapidly becoming specialised. So many factors that call for special attention enter into the production of suitable castings. Most of the standard sizes of

XUM

rings are now cast in chills in centrifugal machines. No hard-and-fast rules for composition of the finished ring can be laid down, as an iron that is suitable for sand castings is quite unsuited to centrifugal castings. In the latter the silicon content is high, generally in the neighbourhood of 4 per cent., whilst in sand castings the silicon runs under 2 per cent. The desirable property in piston rings is elasticity; a property which determines the pressure on the walls of the cylinder, and a considerable amount of research work on this type of casting has been carried out. The importance of the functions of piston rings cannot be over-estimated, and to the position of the rings on the piston, and the elasticity of the iron, are due much of the success of an engine.

A works test for piston rings which is rapidly coming into favour is that which determines the pressure required to close the gap. This test was devised by the British Piston Ring Co., who make a machine for the purpose. The ring to be tested is inserted in a frame in which the ring makes contact at three points, and pressure can be applied to the ring diametrically. The pressure required to just close the gap is read on a small pressure gauge or spring balance. Once the machine is set for any one diameter ring, several hundred can be tested in a very short time. For rings from 65 to 90 mm. outside diameter, a good reading is 8 lbs. pressure. A ring giving a reading of less than 6 lbs. pressure would be considered of low elasticity. A common workshop test for piston rings is to hold the ring at each side of the slot, bend it sideways in opposite directions, and see if there is any permanent set. This is a most unfair test, and one under which even the best piston-ring iron will fail. It is time such crude tests were discarded and more scientific tests substituted.

Motor Car Flywheels.

A motor-car flywheel may appear to be a simple casting, but it presents several interesting metallurgical problems. It might be thought that any sort of iron would be good enough for this casting, but its functions are peculiarly varied. The inside face of the flywheel often serves the purpose of transferring the drive from the crankshaft to the gearbox through the clutch plates: that is to say, the flywheel is part of the clutch. It is therefore necessary that the material should have a high co-efficient of friction, without undue wear taking place. The rim of the flywheel stores up energy, and is subjected to stresses tending to disintegration. It is obvious that a strong ir is essential. On the Rover car teeth are cut on the outer rim of the flywheel to engage with the pinion of the self-starter; on a stiff engine these teeth must stand up against considerable shearing stress. The flywheel thus has three duties to perform, each necessitating somewhat different properties. The castings are usually made from an iron containing approximately T.C. 3.2, silicon 2.0, with phosphorus and manganese each being 1.0 per cent.

Other Castings.

The only other castings which present any peculiarities are brake liners and exhaust branches. The former need to be a medium hard iron, the function of the brake liner being to develop frictional properties when in contact with a fabric or another metallic surface. Experience has taught us that there is no definite analysis which gives the best results, as so much depends on the thickness of the casting and the conditions under which it is cast. As a general rule, an iron of just over 3 per cent. total carbon, and silicon in the neighbourhood of 2.25 per cent. is sought. It is exceedingly difficult to define exactly the length of useful life such a casting should have, as conditions of use vary enormously, according as the car is driven. A very hard iron would tend to polish and not be an effective braking surface: a soft iron would give rapid wear, necessitating frequent adjustments of the brakes and early renewal of the liner.

Exhaust branches require to be fairly soft but close-grained, and not subject to growth or distortion from repeated heating and cooling. The requirements are physical rather than chemical, and any iron in which the graphite is in a finely-divided state should be suitable.

The particulars given in this paper may appear to be sketchy, but is not our knowledge of cast iron of a very sketchy nature? Let us consider for a moment some of the outstanding problems. What do we know of the actual changes involved during the melting of iron in the cupola?

What knowledge have we of the actions taking place in a mould from the time of pouring until the casting is cold? What is the precise effect of mass on the cooling of cast iron? How little we know of the effect of rate of cooling, and less still of the effect of rate of melting! Do we know what differences, if any, are caused in physical properties by rapid melting as against slow melting? Is not our knowledge of the effect of casting temperature on the physical properties of cast iron of the vaguest description?

Do we know if any differences exist in the effective life of cylinders due to temperature of casting? What is the extent of our knowledge of the balance of the various constituents of cast iron, and the possible effect of minute changes in chemical composition? What data have we on the "ageing" of cast iron?

Do we know anything of the possible changes wrought on cast iron by sand composition, grain size, refractoriness, and permeability of sand? What do we know of the changes which take place in the mould when iron is passing from the liquid to the solid state, and the disturbances possibly caused by local chill? Have we any definite information as to the changes which take place on repeated meltings? What knowledge have we as to the effect of atmospheric humidity on the cupola blast?

Are we able to state definitely in what manner the various constituents are split up or combined when cast iron is in the molten state? What is the extent of our knowledge on fatigue of cast iron, due to repeated vibrations: or the influence of chemical and physical composition on fatigue? These are but a tithe of the problems on which we seek enlightenment. A calm survey of the situation can only lead to the conclusion that, in connection with the physical and chemical properties of cast iron, our ignorance is colossal.

DISCUSSION.

A member raised the point that in the analysis given 2 per cent. silicon was very low.

Mr. Russell said there was a very fair amount of free carbon.

The Member: Yes, but not too great for this type of light casting.

Mr. Goodman remarked it was difficult to criticise a man on his address in his absence, and was hardly fair, but there were a few things he did not agree with. They made for over 20 different motor people, who were very particular. He did not agree with the transverse test, but it was very essential.

Mr. Russell said he did not know that silicon varied in particular parts of the casting—the least silicon was in the thickest part, the medium found in the barrel, and the most silicon found in the jacket.

They would have had a good discussion if Mr. Hurren had been present, and the Secretary would communicate with him on some points on which they would like to know further.

This was the last meeting of the session, but they were hoping to have a joint meeting with Sheffield in a visit to the Staveley Coal and Iron Works, near Chesterfield. They had very pleasant recollection of the last visit to that district.

American Iron and Steel Institute.—The twenty-fifth general meeting of the American Iron and Steel Institute will be held at the Hotel Commodore, New York, on Friday, May 23. The Papers to be read are as follows:—(1) The Manufacture of Steel for Ordnance Purposes, by Commander J. B. Rhodes, U.S. Navy Yard, Washington. (2) The Influence of the Composition of Iron Ores on the Cost of Manufacture of Pig-Iron, by H. Foster Bain, director U.S. Bureau of Mines. (3) Selling Practices in the Steel Industry, by Ernest T. Weir. (4) Uniform Coking Coal as a Factor in Blast-Furnace Economy by Walter Mathesius. (5) Hardened and Ground Rolls, by J. R. Adams. (6) Power Requirements for Rolling Steel, by Gordon Fox. (7) Gas Cleaning, Wet and Dry Methods, by G. M. Hohl.

The Use of Fluxes in the Melting of Aluminium and its Alloys.*

By Walter Rosenhain, B.A., D.Sc., F.Inst.P., F.R.S., and S. L. Archbutt, F.I.C., of the National Physical Laboratory.

The strong chemical affinity of aluminium for oxygen and the consequent rapid formation of oxide when unprotected aluminium or alloys rich in aluminium are exposed to contact with air at high temperatures, suggests at first sight that the use of protective coverings and particularly of fluxes would be eminently desirable if not essential in the melting of these materials. In practice, this is not found to be the case and a large proportion of industrial melting of aluminium and its light alloys is carried out without the aid of any flux or protective coating whatever. The reason for this practice is not far to seek: it resides in the fact that the oxide skin which is formed on aluminium or alloys rich in aluminium is very tough and appears to be largely impervious to oxygen, with the result that, once formed, it only thickens slowly and serves as an excellent protection to the metal below. It has been suggested that this oxide coating, which consists probably of Al_2O_3, is capable of reacting with molten aluminium in contact with it, forming a sub-oxide which is soluble in and diffuses through the aluminium, which it is supposed to damage. In itself this suggestion does not appear very probable in view of the fact that a lower oxide of aluminium is not known to chemists. Further, recent researches on the behaviour of aluminium which has been repeatedly remelted and thus exposed for a prolonged period to the possibility of such an action, has shown conclusively that the material is not damaged by such a proceeding. There is also some evidence to indicate that no oxide of aluminium is at all readily soluble in the molten metal and that the formation of oxides both in aluminium and in aluminium-rich alloys is confined essentially to the surface, whether the material be in the liquid or the solid condition.

In these circumstances, one of the main functions for which slags or fluxes are usually employed, namely that of protecting the surface of the molten metal from oxidation, becomes unnecessary in the case of aluminium or its alloys. The affinity of aluminium for oxygen is such that oxides of other metals, such as copper or zinc, cannot persist in the presence of a large excess of aluminium, and these metals, when present in alloys, are therefore protected completely by the aluminium and its oxide skin. This does not apply with equal force to such elements as silicon and magnesium, since silica can only be reduced with difficulty and at a red heat by an excess of aluminium in the metal. It is perhaps significant in this connection that the only alloy of aluminium which is habitually used with a flux is the alloy containing from 12 to 14 per cent. of silicon. It is true that the function which this flux is supposed to perform lies in a different direction, to which reference will be made below, but its effect in protecting silicon from oxidation must not be neglected.

The great stability of the oxide of aluminium, with the action of fluxes on aluminium and its reduced by other chemical agencies, is a further factor which must be considered in connection with the action of fluxes in aluminium and its alloys. Reducing fluxes intended to reduce the oxide of the metal are practically inapplicable to aluminium and its alloys, and the only method of removal of an oxide skin which can be brought into play by the use of fluxes must consist in the solution of the oxide in the molten flux. It is for this reason that the fluxes which have proved most successful where it has been necessary to remove the oxide from aluminium or its alloys are those consisting of halogen compounds mainly of the alkali metals and including the chlorides and fluorides of potassium, sodium, and lithium. It is well known that in the production of aluminium by electrolytic means the electrolyte consists of molten cryolite holding in solution about 5 per cent. of alumina, this mixture having the lowest melting-point of the series at about 915 deg. C. This temperature is too high for use in the melting operations connected with aluminium and its alloys, and a fluoride or halide flux to be useful in those operations must therefore consist of a mixture having a considerably lower melting-point than the cryolite-alumina solution. Such mixtures are obtained by the addition of alkali metals, generally in the form of chlorides or fluorides to the cryolite mixture; somewhat similar results can also be achieved by mixtures of the chlorides and fluorides alone, without the presence of cryolite. Fluxes of this kind are undoubtedly able to dissolve oxide of aluminium, and where it is necessary that the oxide coating should be removed in order, for instance, to allow the molten particles of metal to run together as in the melting of swarf or in welding of solid aluminium or aluminium alloys by means of the electric arc or acetylene flame, the use of such fluxes is general and successful. On the other hand, their use has certain disadvantages and serious difficulties. These are due in the first place to the difficulty of preventing contamination of the molten aluminium by enclosure of particles of flux. This difficulty arises from the fact that the density of the molten metal itself is not very much greater than that of the molten flux and consequently if globules of molten flux become entangled in the metal they do not separate very quickly and are liable to be carried forward into the casting when the metal is poured from the crucible or ladle. This disadvantage is so serious that in many cases it renders the use of flux undesirable. Where the use of flux is unavoidable, as for instance in the electrolytic preparation of the metal itself, it is generally desirable to remelt the metal after a first casting, in order to allow entangled particles of flux to rise to the surface and become separated.

Another difficulty connected with the use of fluxes of the type mentioned, consisting of chlorides and fluorides of the alkali metal and sometimes of zinc, is the fact that they are apt to exert a violent chemical attack upon the crucibles in which the metal is melted. Silicious materials such as fireclay, etc., are rapidly attacked by fluoride melts. Beyond this, the porous crucible walls absorb the molten flux in considerable quantities and are much injured thereby. This damage is enhanced by the fact that many of these fluxes, when allowed to cool, become hygroscopic and bring about a very undesirable condition of the crucible, frequently rendering it impossible to use it successfully a second time. Where aluminium alloys are melted in iron vessels, on the other hand, this effect is much less marked. In this case, however, it is generally necessary to protect the surface of the iron by some kind of protective coating or wash which prevents the direct solution of iron by the aluminium. Such a wash is rapidly attacked by fluoride or chloride fluxes and their use is apt to lead ultimately to the attack of the iron vessel by the aluminium with consequent damage to both.

The general conclusion to be drawn from the considerations and facts set out above is that, whenever avoidable, fluxes should not be used in the melting of aluminium and its alloys. The prevention of an undue amount of oxidation is best achieved by minimising the temperature to which the molten metal is exposed, reducing the time of such exposure and carefully avoiding any undue agitation of the surface. It is sometimes thought that aluminium which has been molten and cast, whether pure metal or alloy, contains a considerable amount of oxygen. The view held by the present writers, however, based upon definite experience, is that there is reason to believe that the oxygen content of aluminium when properly treated is extremely low. The so-called "burning" effect which is sometimes observed in practice is almost always traceable to contamination

* Paper read at the recent symposium on Slags and Fluxes arranged by the Faraday Society, the Institute of Metals, the Institute of British Foundrymen, and the Non-Ferrous Research Association.

of the metal by impurities other than oxygen. Where pure materials are used and scrupulous cleanliness is observed, no deterioration on repeated remelting need occur.

Reference has already been made to certain circumstances in which the removal of an oxide film is essential to successful operation, as for instance in the remelting of finely divided swarf or scrap. For this purpose a flux partly consisting of cryolite has proved very successful in the authors' experience. The mixture used contains 40 per cent. of cryolite and 60 per cent of potassium chloride. Another mixture recommended by Livermore, which is also successful, contains sodium chloride 85 per cent., and calcium fluoride 15 per cent. These proportions, however, must only be regarded as typical of suitable mixtures for this purpose, other compositions of similar ingredients, as indicated above, being probably equally satisfactory.

"Alpax" Alloy.

A flux of a very special kind has recently been introduced for a particular purpose in connection with the alloys of aluminium and silicon, known under the trade name of "Alpax," "Silumin," etc. The use of this flux, which is protected by a patent, brings about a modification in the character of the alloy itself, leading to a different method of crystallisation and a very fine microstructure which brings with it superior mechanical properties. The flux in question is a fluoride flux containing a notable proportion of sodium salt and it is suggested that the molten aluminium-silicon alloy is capable of reducing from this flux a small amount of metallic sodium. The modification of the microstructure of the resulting alloy is ascribed to the influence of this small amount of sodium, and this view is confirmed by the fact that somewhat similar results can be obtained by the direct addition to the molten alloy of a corresponding small quantity of metallic sodium. The suggestion that molten aluminium-silicon alloys are capable of reducing sodium from a fluoride flux is at first sight somewhat startling, but when it is remembered that the amount of aluminium alloy present is very large when compared with the amount of the flux with which it is in contact, a small sodium content in the alloy as the result of a balanced action is not perhaps difficult to understand. In the earlier stages of the metallurgy of aluminium, when the metal was prepared by reduction with sodium, the presence of a small proportion of sodium in the resulting metal was regarded as a serious disadvantage leading particularly to corrosion troubles. The amount of sodium remaining in the modified aluminium-silicon alloy may, perhaps, be much smaller than that left in the pure metal when reduced by sodium, but at all events its presence does not appear to make itself felt in any undesirable manner in regard to corrosion. The properties and behaviour of these alloys and the manner in which sodium affects their microstructure is, however, a matter outside the scope of the present discussion.

Although in this note attention has been confined to the use of fluxes in the melting of aluminium and its alloys, brief reference may also be made to the uses of fluxes in the soldering and welding of aluminium and its alloys. In regard to soldering, which is generally carried out by what are known as aluminium solders consisting as a rule of alloys of zinc, tin and aluminium, the use of various fluxes has from time to time been recommended. A considerable number of tests of aluminium soldering processes and of the resulting joints carried out both at the Bureau of Standards at Washington, U.S.A., and by the National Physical Laboratory, have led the investigators concerned to come to the conclusion that the use of fluxes in this process is undesirable, and that better results can be obtained in their entire absence. The use of fluxes in the welding of aluminium and its alloys, however, appears to be a matter of somewhat greater importance. It is a question which has been very fully discussed in connection with patent litigation, so that it is perhaps unnecessary to enter further into it here, beyond mentioning the fact that the fluxes used are mainly alkali halide mixtures very similar in type to those to which reference has been made in connection with melting.

Contracts Open.

Bungay, May 26.—Pumping machinery—Supply and erection of two crude oil engines of 17 b.h.p. and two vertical treble ram pumps of 7,500 gallons per hour capacity, for the U.D.C. Taylor & Wallin, Commercial Union Buildings, 47, Pilgrim Street, Newcastle-on-Tyne. (Fee, £5, returnable.)

Dublin, June 2.—Railway stores, for the Midland Great Western Railway of Ireland Company. Storekeeper, General Stores Department, Broadstone Station, Dublin. (Fee, 6d.)

Garw Valley, etc., May 21-June 9.—Cast-iron pipes, etc., for the Mid-Glamorgan Water Board. Thomas & Morgan & Partners, 23, Gelliwastad Road, Pontypridd. (Fee, £5 5s., returnable.)

London, E.C., May 27.—(a) Steel tyres and (b) axlebox faceplates, for the Bengal-Nagpur Railway Company, Limited, 132, Gresham House, Old Broad Street, E.C.2. (Fees, 20s. for (a) and 10s. for (b), non-returnable.)

London, S.W., May 23.—Laminated springs and spring steel, for the South Indian Railway Company, Limited, 91, Petty France, Westminster, S.W.1. (Fee 5s.)

London, W., May 27.—184 tons of steel girders and other steel and iron work of British manufacture, for the Great Western Railway Company. The Engineer, Paddington Station.

Melbourne, June 25.—Rails and fishplates, for the Victoria Railways. Department of Overseas Trade, 35, Old Queen Street, London, S.W.1.

Obituary.

MR. T. WOOF, London manager of Alfred Herbert, Limited, machine tool makers, of Coventry, died recently, aged 65 years.

MR. EDWIN THORNLEY, joint managing director of the Southport Engineering Company, King Street, Southport, died recently, aged 55.

We regret to announce the death of Mr. W. H. Cook, of Wellington Road, Heaton Chapel, Stockport, who was a member of the General Council of the Institute of British Foundrymen.

MR. S. UTTING, of Grosvenor Mansions, 82, Victoria Street, London, a well-known engineer, died recently. An associate member of the Institution of Electrical Engineers, and a member of the Institution of Mechanical Engineers, he was known particularly in connection with the Louis Prat System of induced draught.

MR. THOMAS BURTON, J.P., works manager of Monks, Hall & Company, Limited, of Warrington, died on April 30, at the age of 84. The deceased gentleman had throughout his life been intimately connected with the iron trade, having at an early age been engaged at the works of Thornycrofts & Company, Wolverhampton. He was also at the Dallum & Bewsey Forges, Warrington, and was afterwards on the staff of the Whitecross Company.

MR. KENNETH P. HAWKSLEY, the well-known consulting engineer, died in London on May 2. A partner in the firm of T. and C. Hawksley, he was a grandson of the late Mr. Thomas Hawksley, and a son of the late Mr. Charles Hawksley, both of whom were past-presidents of the Institution of Civil Engineers. The deceased gentleman held the position of consulting engineer to waterworks undertakings. He was elected to the Council of the Institution of Civil Engineers in 1921, and was also a member of the Institution of Mechanical Engineers, and the American Society of Civil Engineers.

Gazette.

MR. JUSTICE ROMER has made an order to wind up compulsorily the Re-Echo Electrical Manufacturing Company, Limited.

THE PARTNERSHIP heretofore subsisting between R. Roberts and J. Roberts, Bersham Foundry, near Wrexham, under the style of the Bersham Foundry Company, has been dissolved. Mr. Roberts will continue the business.

THE FIRST MEETING of the creditors of Mr. D. E. Jones, electrical contractor, carrying on business as D. Emrys Jones & Company, 29, Carne Street, Pentre, will take place on May 22. The public examination will be held on June 13 at the Court House, Court House Street, Pontypridd.

On the Working Slags in Ferrous Processes.*

By J. E. Fletcher, M.I.Mech.E.

(*Continued from page* 398.)

During the working of an acid open-hearth charge the SiO_2 content gradually increases whilst the FeO and MnO content (sum) decreases.

In Table IX and Fig. 9 this action is clearly illustrated.

As the operation progresses the inert constituents (*a*), (*b*) and (*c*) form, and in high-temperature melting in strongly oxidising furnaces some of the FeO is oxidised to Fe_2O_3, which, acting as an acid, unites with CaO to form the inert constituent

TABLE IX.—*Composition of Open-Hearth Furnaces.*

	FeO MnO	SiO_2	CaO	AlO_3, etc.	2FeO SiO_2 MnO	Free SiO_2	2CaO SiO_2	Free SiO_2 / 2RO SiO_2
A	42.7	52.4	—	4.8	60.6	34.2	—	0.56
	40.4	55.8	—	3.8	57.0	39.2	—	0.68
	40.0	55.8	—	4.1	56.8	39.2	—	0.68
	39.3	55.7	—	4.9	55.7	39.3	—	0.70
B	42.0	48.2	7.5	2.3	59.5	25.5	13.0	0.35
	34.2	54.6	9.0	2.0	48.0	31.7	12.3	0.52
	32.0	57.0	9.4	1.6	45.2	41.2	11.6	0.73
	FeO MnO	SiO_2	CaO MgO	Al_2O_3, etc.	2FeO MnO SiO_2	Free FeO & MnO	2CaO MgO SiO_2	Free FeO / 2RO SiO_2
C	63.3	20.7	9.7	6.3	52.0	26.7	14.8	0.41
	59.8	20.4	12.0	7.8	47.3	26.9	18.5	0.41
	59.8	18.3	12.7	9.2	39.0	32.3	19.5	0.55
	56.7	18.5	18.1	6.7	30.1	35.5	27.8	0.61
	51.3	18.1	22.5	8.1	20.8	36.7	34.5	0.67

The series of slags A are illustrative of a charge worked with ore additions. In B a small amount of lime has been added with the ore.

In C the lime additions have been more liberal and the slag has thereby been changed to the basic type. Here the ortho-silicates, $2ROSiO_2$, dissolve the excess FeO and MnO.

The author has shown here his view of the difference between acid and basic slags.

3 CaO, FeO_3 found by Stead in basic slags. Wilson has illustrated several cases of slags which were almost perfectly inert at the moment of the tapping of the steel. (I. & S. Inst., 1920.)

In Table X the progress of a basic open-hearth heat is shown, the example being taken from Petersen's pamphlet in the "Hoesch" Process, 1910, and quoted by J. F. Wilson in his Paper on "Slag Conditions in Basic Steel Making,"

TABLE X.—*Composition of Basic Open-Hearth Slags.*

CaO MgO	P_2O_5	FeO & MnO	SiO_2	Al_2O_3, etc.	5 CaO P_2O_5	2CaO MgO SiO_2	2FeO MnO SiO_2	Free SiO_2
45.6	22.8	15.3	12.2	3.9	65.0	5.7	21.8	3.8
49·5	22 4	12.0	11.8	4.3	63.7	12.6	17.0	2.4
52.9	22.1	8.6	11.4	5.0	63.1	18.3	12.2	1.4

Whiteley and McCance have pointed out the presence of the minerals olivine, fayalite and silica as cristobalite and tridymite, in acid open-hearth slags, these minerals being present in a matrix of glassy character (free silica).

This fact strongly supports the view that the

I. & S. Inst., 1920. Here is the case of a slag which is progressively advancing towards the neutral or inert condition, the slag being feebly acid (SiO_2 content, 1.4 per cent.) at tapping. Another case where lime additions have been liberal is indicated in Table XI:—

TABLE XI.—*Influence of Liberal Lime Additions on Open-Hearth Slag Composition.*

CaO + MgO	P_2O_5	FeO & MnO	SiO_2	5CaO P_2O_5	2 FeO MnO SiO_2	2MgO CaO SiO_2	Free CaO
39.1	14.5	21.1	11.2	41.1	29.9	7.0	6.3
39.7	14.0	20.2	10.9	41.8	28.4	7.0	7.4
44.0	13.1	18.5	10.1	39.3	26.2	6.9	13.3
48.6	12.0	17.3	9.3	35.8	24.5	6.0	20.9

molten slags are composed of the ortho-silicates of lime, iron and manganese of $2ROSiO_2$ form, in which are dissolved either excess SiO_2, or FeOMnO.

In acid slags the silica is dissolved, and in basic slags the solutes are FeO and MnO.

Basic Hearth Slags.

In the normal basic open-hearth working the liquid slags appear to consist of:—

(*a*) Ortho silicate, 2 CaO, MgO, SiO_2.
(*b*) Ortho silicate, 2 FeO, MnO, SiO_2.
(*c*) Neutral CaO, P_2O_5, 5 CaO, P_2O_5.
The neutral constituent, 3 CaO, Fe_2O_3.
(*d*) Free CaO, FeO, MnO, separately or conjointly. Or
(*e*) Free SiO_2.

* A paper presented to the Birmingham Branch of the Institute of British Foundrymen, Mr. J. B. Johnson presiding.

In this example the slag was approximately neutral or inert when lime additions were made, and is typical of Talbot open-hearth practice. As an illustration of a basic heat in which iron ore and lime were added, the former in excess (Table XII) is given:—

Puddling Slags.

In the interesting puddling process the first slags are formed during the oxidation of the charge. These run down into the liquid fettling on the furnace hearth and mix with them.

Here again, as the process advances from the melting, through the boiling and refining stages, the slags become increasingly inert, being mixtures of the inert constituents 2 (FeO MnO) SiO_2, 5 FeO P_2O_5, 3 FeO Fe_2O_3, with either free silica or free ferrous oxide in solution.

The alteration in slag composition as a puddling heat progresses is shown in Table XIII and Fig. 10 (A, B, C and D), the first analysis being that of the slag when the charge is just melted, the last when the balling period commences. The influence of oxidation during the last period is clearly

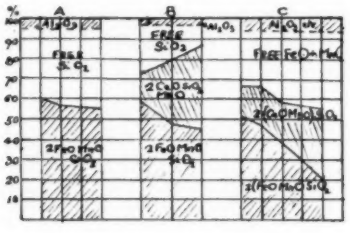

FIG. 9.—ACID OPEN HEARTH PROCESS.

shown. There is here depicted the case of a slag which, during the working of a charge, changes from acid to basic in its nature, just passing the inert stage.

The slag which is squeezed or hammered from the puddled ball is of similar character, but the interesting point revealed on examination of the constitutional analysis is that the hammered slag is almost perfectly neutral, as Table XIII shows, item "E." The slags taken from reheating furnaces are of the rich iron oxide variety, and illustrate the tendency towards the formation of the

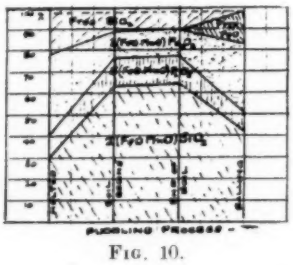

FIG. 10.

neutral constituent 3 FeO, Fe_2O_3. Indeed, the slag "F" indicates the presence of 76.5 per cent. of this inert product. When slowly cooled, these slags reveal the presence of magnetite and crystals of ferrous oxide, ferrous silicate FeO SiO_2 (grünerite) and fayalite olivine 2FeO SiO_2.

tion of Dr. Stead—is of considerable interest. By adding increasing amounts of lime to a basic slag a series of slags are obtained as given in Table XV and Fig. 11. By considering the fluid composition as consisting of the neutral silicates 2CaO SiO_2 and FeO SiO_2, the ferrate 3FeO Fe_2O_3, the neutral phosphate 5CaO P_2O_5 and free CaO, the constitutional analysis is shown alongside the bulk chemical analysis.

TABLE XIV.—*Re-Heating Furnace Slags.*

FeO & MnO	Fe_2O_3	SiO_2	3FeO MnO Fe_2O_3	2FeO SiO_2	Free FeO
67.48	30.40	1.58	71.80	5.36	22.30
70.80	25.35	3.84	59.70	13.15	27.14
74.72	20.50	4.75	48.30	16.17	35.50

The view has been taken that the iron oxides present in the liquid state, after the formation of the silicate, occur as the neutral constituent 3FeO Fe_2O_3. The change from the acid, the neutral and then to the basic condition is clearly evident.

In conclusion, the author regrets, through lack of time, his inability to prepare micrographic illustrations of the various slags described, but would refer those interested to the published work of Vogt, Akermann, Gredt, Juptner, Whiteley and McCance on ferrous slags and refractories, whose investigations of the structures of cooled slags have thrown such a flood of light on the problem.

TABLE XII.—*Influence of an Excess of Iron Ore in Basic Open-Hearth Practice.*

CaO + MgO	P_2O_5	Fe_2O_3	MnO FeO	SiO_2	5CaO P_2O_5	2FeO MnO SiO_2	3 FeO Fe_2O_3	2 Mgo CaO SiO_2	Free FeO MnO
13.2	2.9	4.9	56.5	19.0	8.7	51.0	11.5	11.4	13.9
39.5	2.5	2.0	29.5	23.0	7.5	15.3	4.7	53.0	16.0
42.3	2.0	2.4	26.9	22.9	6.0	7.5	5.6	59.0	18.4
44.1	1.7	2.2	26.2	22.3	5.1	1.0	5.2	62.7	22.5

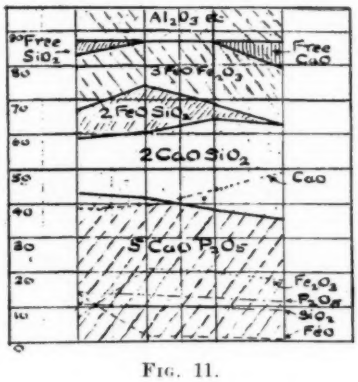

FIG. 11.

The chief aim has been to draw attention to the following practically important conclusions of the author in his investigations on ferrous slags:—

(1) That in the liquid condition at temperatures well above their fusion points such slags become equilibrated solutions of inert constituents containing decreasing quantities of the active oxide or oxides.

(2) That these dissolved free oxides show by their content the acidity or basicity of the slags.

(3) That the alloying or reducing actions produced in the metal in contact with the slags are brought about by the free oxides which, under con-

(*Continued on page* 432.)

TABLE XIII.—*Alteration of Composition in a Puddling Furnace.*

	FeO & MnO	Fe_2O_3	P_2O_5	SiO_2	2FeO MnO SiO_2	5FeO P_2O_5	3FeO Fe_2O_3	Free SiO_2	Free FeO
A.	48.0	18.5	3.5	28.0	30.6	10.4	38.0	19.0	—
B.	59.5	5.2	4.8	27.5	63.3	14.2	10.7	8.8	—
C.	60.8	6.3	4.5	27.0	64.4	13.3	12.9	8.0	—
D.	69.0	9.8	3.2	15.8	41.35	9.5	20.1	—	14.7
E.	61.3	16.5	1.0	17.1	41.1	3.5	33.8	0.10	—
F.	50.5	38.5	0.5	10.5	19.1	1.8	75.0	4.9	—

McCance has thrown very useful light on the constitution of the cooled products of decomposition ("Journal I. & S. Inst.," 1918; Vol. 1), and in Table XIV the author seeks to suggest the molten constituency of three of the slags McCance has described and illustrated by very clearly-defined micro-photographs.

A further note on the decomposition of open-hearth basic slags—a series of experiments carried out by F. Bainbridge, of Saltburn, at the instiga-

The "VULCANIA" PATENT WHEEL MOULDING MACHINE.

Patent No. 5049.

THE "VULCANIA" PATENT WHEEL MOULDING MACHINE is for moulding spur wheels with straight, sloping or Vee-shaped teeth, also bevel wheels, skew gear wheels, worm wheels and internal wheels. The machine head is carried on a pillar which is held in a base-plate bedded in the floor sand, and is made to slide on the pillar by means of a lever and link carried on a joint bearing, or by rack and pinion, or screw if thought advisable for the particular work it is being used for.

An adjustable stop collar is provided for accurately deciding the depth of mould. On the removable head a slide is carried for supporting the patterns of the teeth to be moulded. This slide is made adjustable by screw or pinion gearing to the diameter required. The number of teeth to be moulded is decided by a special dividing plate into which a steel wedge or finger engages. The special dividing plate has milled vees, at the angle of 60° inclusive, around its circumference, to receive the steel wedge, which is adjusted by a screw having an internal spring to keep it in tension and to lock the head when ramming operations are being carried out.

JAMES EVANS & CO., BRITANNIA WORKS (MANCHESTER), LIMITED.

BLACKFRIARS, MANCHESTER.

ditions of superheat beyond the true fusion temperatures of the slags and metals, and by possible catalytic action, react with the constituents in the metal.

(4) That the tendency during the various smelting and refining processes described is for the oxides to combine in groups of neutral or inert constituents until the acid and basic oxygen ratio of the slag attains unity. Thus slags containing a free acid oxide gradually become inert by the addition of basic material, or by the reduction of the acid oxide. When the inert point is reached further basic conditions or acid abstractions produce a condition where the composition is that of a neutral slag containing excess basic oxide or oxides in solution.

(5) That under certain oxidising conditions in the furnace atmosphere the iron oxides formed tend to the formation of constituents of neutral character, the ferrous and ferric oxides combining in the ratio $\frac{Fe_2O_3}{3FeO}$ and other basic and acid oxides in the ratio $\frac{R_2O_3}{3RO}$

(6) That the inert constituents of types ($2RO.SiO_2$), ($5RO.P_2O_5$), ($3RO.R_2O_3$) are the stable forms at sufficiently high temperatures, decomposing on cooling to meta-stable constituents as ($RO.SiO_2$) and the transition products of the decomposition of the stable forms, in which forms they are commonly discovered when the cooled slags are microscopically examined.

Table XV.—*Influence of Increments of Lime on Basic Slags.*

CaO	P_2O_5	FeO	Fe_2O_3	SiO_2	$2CaO\ SiO_2$	$3FeO\ Fe_2O_3$	$5CaO\ P_2O_5$	$2FeO\ SiO_2$	Free SiO_2
39.1	14.48	14.79	7.0	11.20	16.0	16.4	43.18	7.65	3.35
39.7	14.00	1.16	21.29	10.90	18.6	11.95	41.60	14.9	—
44.0	13.12	0.51	20.43	10.10	28.1	18.00	38.82	4.1	—
48.6	11.99	0.51	18.71	9.30	26.9	19.22	35.49	—	Free CaO 7.7

Company News.

J. & E. Hall, Limited.—Interim dividend, 6d. per share.

Vickers, Limited.—No dividend on ordinary shares for 1923.

Kerr, Stuart & Company, Limited.—Interim dividend, 8 per cent. per annum.

Tweedales & Smalley (1920), Limited.—Final dividend, 12½ per cent. actual, making 25 per cent. for year.

Marbella Iron Ore Company, Limited.—Loss, £4,310; debit balance brought forward, £4,998; net debit balance, £9,308.

Mirrlees, Bickerton & Day, Limited.—Preference dividend, 5½ per cent. per annum; ordinary dividend, 7½ per cent. per annum.

Anchor Cable Company, Limited.—Profit, £18,420; debenture interest, £2,250; dividend for year, 20 per cent.; carry forward, £99,133.

Westall & Company (Burnley), Limited, Albert Mill, Varley Street, Burnley.—Capital £1,500 in £1 shares. Founders. Directors: T. Westall, W. Kenway and G. Clayton.

Metrolyte, Limited, Moland Street, Birmingham.—Capital £2,000 in £1 shares, to acquire the business of metal craftsmen and brass founders now carried on by Elsie Bridgwater and F. A. James.

Basson Electrical Company, Limited, 32, Station Road, Swinton, Lancs.—Capital £500 in £1 shares (100 5 per cent. cumulative preference). Permanent directors: E. L. Castle and H. Basson (manager).

Jenkins Brothers (Birkenhead), Limited, 32, Neptune Street, Birkenhead.—Capital £1,000. Founders, engineers, manufacturers of machinery, etc. Directors: L. D. Holt, L. H. Cripps and S. B. Freeman.

English Crown Spelter Company, Limited.—Credit balance, £2,331; brought forward, £2,289; transferred from equalisation of dividend reserve to profit and loss, £5,000; dividend, 2s. per share, less tax; carry forward, £1,932.

Callender's Cable and Construction Company, Limited.—Net profits, £264,085; brought forward, £226,901; final dividend, 2s. per share on ordinary shares, making 3s. per share (15 per cent.) for year; carry forward, £315,987.

Personal.

Mr. I. Davies, the accountant to the Bwllfa and Merthyr Dare Steam Collieries (1891), Limited, has been appointed secretary to the company in succession to the late Mr. T. E. Malyon.

Sir Archibald C. Ross has presented a handsome solid gold and enamelled medallion, to be worn as a badge of office by the chairmen of the Middlesbrough Branch of the North-East Coast Institution of Engineers and Shipbuilders.

Mr. C. F. Mackness has resigned his position as chief engineer of the hydro-electric department of Vickers, Limited, Westminster, London, S.W.1, and has established himself in business at 37, Norfolk Street, Strand, W.C.2.

Trade Talk.

The Foster Engineering Company, Limited, have removed their Glasgow office from 67, Waterloo Street, to 27, Blythswood Square.

Swan, Hunter & Wigham-Richardson, Limited, Wallsend-on-Tyne, have just secured a contract for a vessel 500 ft. in length.

The Vickers-Spearing Boiler Company, Limited, 20, Kingsway, London, W.C.2, have recently acquired the sole British and Colonial manufacturing and selling rights of the Illinois chain grate stokers.

His Royal Highness Prince Arthur of Connaught will be the principal guest at the official banquet of the Empire Mining and Metallurgical Congress. The banquet will be held at the Guildhall on June 5.

At their works at Wallsend the North-Eastern Marine Engineering Company, Limited, have started on a non-stop run at full load for 20 days a large double-acting Diesel oil engine, which is the joint production of the firm and Messrs. Werkspoor, of Amsterdam, after two and a-half years' experimenting. The engine consists of a number of single-cylinder units working together on one common crankshaft. A distinctive feature is the direct transmission of power from a single piston, through a single piston rod to the cranks, exactly as in the normal marine steam engine. The aims of the designers at simplicity, accessibility and reliability have been well achieved. The unit is of the following dimensions:—Cylinder bore 800 mm. (31½ inches); stroke, 1,400 mm. (55 inches full). In continuous service at 95 r.p.m., 750 i.h.p., and 600 b.h.p.: maximum power, 1,000 i.h.p.

Further Carnegie Scholarships.

During the proceedings of the Iron and Steel Institute annual meeting, recently, The Secretary (Mr. G. C. Lloyd) announced that Carnegie Research Scholarships had been awarded to the following:—

C. H. Adamson (Sheffield) and G. S. Bell (Lincoln).—£100 jointly to carry out an investigation of transverse test bars of cast iron of various mixtures.

L. Aitchison (Birmingham).—A second grant of £100 to study the critical quenching velocity of steel, the influence of composition upon it, and its effect upon the influence of mass in hardening.

C. E. Pearson (Newcastle-on-Tyne).—£75 to investigate the growth of commercial grey cast-iron.

E. R. Taylor (Birmingham).—£75 to ascertain the relationship between sulphur and other ingredients of white iron in connection with the industrial annealing operations for the production of white-heart malleable castings.

It was also recommended that a further grant of £50 be made to Professor O. W. Ellis, of Toronto University, to enable him to install apparatus to continue his investigations, of which a report had already appeared.

YOU CAN TURN OUT
BETTER CASTINGS AT LESS COST
BY USING

Sterling

ROLLED STEEL
MOULDING BOXES

SECTIONS OF STERLING ROLLED STEEL BAR AND STIFF SAND LEDGES SHOWING THE SOLID RIB

SECTIONS OF STERLING ROLLED STEEL BAR AND STIFF SAND LEDGES SHOWING THE SOLID RIB

STERLING FOUNDRY SPECIALTIES, Ltd.
London Office:
13, VICTORIA ST., S.W.1. Sterling Works, BEDFORD.

SIEMENS' STEEL PROCESS

BOILER, SHIP and BRIDGE PLATES, etc. ANGLES and all forms of Sectional Bars. TYRES and AXLES to all requirements. CASTINGS of all kinds and of Largest Sizes. FORGINGS of every description. BILLETS, BLOOMS, RAILS.

SPECIAL STEEL FOR CONSTRUCTIVE PURPOSES.

The STEEL COMPANY OF SCOTLAND, Ltd.

Head Office: 23, ROYAL EXCHANGE SQUARE, GLASGOW.
Works: HALLSIDE, NEWTON and BLOCHAIRN, GLASGOW.
CONTRACTORS TO HOME, COLONIAL AND FOREIGN GOVERNMENTS.
Established 1872. *Telegraphic Address: "Steel, Glasgow."*

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,
FIRE CLAY.

Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.

STEEL MOULDERS' COMPOSITION, SILICA CEMENT.

J. GRAYSON LOWOOD & Co., Ltd.,
DEEPCAR, nr. SHEFFIELD.

Telegrams: "LOWOOD, DEEPCAR."

IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—With only a moderate demand on home-trade account, movements in the Cleveland iron markets are without special significance, but as indicating the tendency of current developments some forward buying is reported covering consumers' requirements over the remainder of the year. The output of Tees-side furnaces at present, however, is comparatively so limited, and the supplies in such few hands, that it would take but a small stimulus of demand to react sharply upon prices. As previously stated, there is still a substantial quantity of iron bought which has yet to be got away, and when this is absorbed a fresh buying movement will certainly follow. Shipbuilding is apparently taking on a more healthy tone, and this should in turn create more active conditions in the foundries. On the other hand, the export outlook is at the moment somewhat beclouded by the political and economic developments on the Continent.

While there is no very marked change in the hematite position, such movement as there is shows an upward tendency. There has been of late a steady, if very slow, expansion, which has enabled makers to reduce their stocks and to get things on a more satisfactory basis.

MANCHESTER.—Conditions in the local market for foundry iron continue practically unchanged, with buying still on a restricted scale. This is natural in the present situation, due to the wages dispute in the foundry trade not being settled, and what the outcome may be is unknown. Hence the small buying, now the prevailing feature of the trade, is accounted for. Makers of Derbyshire iron still quote 95s. on trucks at the furnaces for No. 3 foundry, but there are rumours that less has been accepted when this has been thought necessary to secure an order.

THE MIDLANDS.—Business in this area continues far from satisfactory as far as foundry pig is concerned, a large number of ironfounders in the Black Country stating that orders for castings have fallen off perceptibly, and most of them are covered for their requirements until the end of June. Northants appears to be the weakest market, as supplies are to be obtained at under 92s. 6d. at the furnaces for No. 3 foundry. There is no alteration in the prices quoted by the Staffs and Derbyshire furnaces. The current prices are as follow:—Derbyshire No. 3 foundry, 95s.; Staffordshire No. 3 foundry, 95s.; Northants No. 3 foundry, 92s. 6d.

SCOTLAND.—Buying in the Scottish pig-iron market continues on very quiet lines, any orders coming forward being only for moderate quantities for immediate delivery. There is no change in prices, the nominal quotation for No. 3 Scotch remaining at 100s. at the furnaces, but for actual business less money is being accepted. There has been practically no business done here in Cleveland iron recently, but buyers keep holding off in the hope that before long they may be able to make purchases of Continental iron on better terms. The quotation for No. 3 Middlesbrough is 98s. per ton f.o.t. Grahamston.

Finished Iron.

Little or no improvement can be reported concerning bar iron, whilst the demand for nut and bolt iron becomes weaker. This grade of iron can be obtained at £11 15s., delivered works, as compared with the Belgian price of £8 15s. Deliveries of the latter iron, however, are very slow, and the present offers are for delivery July/August. The makers of marked bars are fairly well employed, and tested iron continues to be in moderate demand. There is no alteration in the prices, marked bars being £15 at makers' works and crown iron from £12 15s. to £13 delivered. The makers of the latter are using every endeavour to establish the higher figure, but the call for crown iron is not sufficient at the present time to enable a stand to be made. An order of any tonnage would cause much competition, and could be placed without difficulty at £12 10s. per ton.

Steel.

Slightly more activity may be noted in Sheffield steel trade branches, but the outlook cannot yet be regarded as by any means satisfactory. There is a fair amount of buying of acid billets, but the volume is below the normal for this time of year. Continental competition in basic billets is practically non-existent, for now that the prices are very little lower than British quotations the home produced goods are preferred. Makers of open-hearth steel are busy, but crucible steel manufacturers are badly off for orders. For tool steel there is a fair demand; in fact, this is one of the best sections of Sheffield industry just at present. Owing to the inability to obtain shipments of ferro-silicon on contracts, there have been heavy calls on stocks, and there is practically no material available in this country for immediate delivery of 45 per cent.

Scrap.

Reports from the various markets for scrap metal again evidence continued inactivity, although in some instances, notably in Sheffield, there has been a slightly improved demand for steel material, while in South Wales heavy qualities in furnace sizes are offered at figures varying between 90s. and 93s. 6d. per ton. Owing to the unsettled labour conditions in the foundry industry the demand for cast scrap is much the same as it was, but Lancashire dealers seem to be a little firmer. If an amicable settlement of the dispute be reached, here will probably be an increased disposition to buy cast scrap, and for this the dealers are waiting. Some of them are now holding the best qualities of cast scrap for 92s. 6d. per ton, but it cannot be said that so much as this has been paid. In Scotland heavy machinery cast-iron scrap has made a slight improvement, and more inquiries are coming forward, but it is difficult to find a buyer at anything over 97s. 6d. per ton, and this is more or less from foundries. Ordinary cast iron in 1-cwt. pieces is 3s. 6d. to 5s. per ton less. Ironworks cast iron in handy pieces has been bought at 90s. per ton, although the demand is rather poor. Good, clean, light cast-iron scrap is 80s. per ton, and if mixed with fire bars about 2s. 6d. per ton less. The above prices are all delivered f.o.t. consumers' works.

Metals.

Copper.—Values in the market for standard copper last week developed a further downward tendency, operators having been adversely influenced by the recent depression in other metals, and some feeling of uncertainty with regard to the immediate industrial outlook. Copper producers of late have kept well in touch with consumers, having made no attempt to inflate their terms, which have simply fluctuated with variations in the open market, and this also applies to manufactured metal. The movement of copper supplies into consumption, taking the whole of the world's consumers, has been certainly more satisfactory in the last month or two, and this has tended to improve prospects after the considerable reduction of the American surplus stocks. Home consumers have shown moderate interest in electrolytic lately. Current quotations:—*Cash*: Thursday, £61 7s. 6d.; Friday, £60 17s. 6d.; Monday, £62; Tuesday, £61 15s.; Wednesday, £61 10s. *Three Months*: Thursday, £62 5s.; Friday, £61 15s.; Monday, £62 17s. 6d.; Tuesday, £62 12s. 6d.; Wednesday, £61 12s. 6d.

Tin.—The dominant factors affecting the position in this market at the moment offer little encouragement to hope for an early return to steadier conditions, the depression in American industries and the uncertainties of Continental political movements combining to induce a lack of confidence with adverse results to movements in the metal. It is generally agreed that the recent fall in metal values is due in a large measure to the action of speculators and not to an over-supply of metal ill-required for consumption. The fact is that the statistical positions are good, and if bull accounts were justified two months ago, they are even more justified now when prices have declined to such a considerable extent. Contrary to what is often the case when prices are low, stocks in the hands of consumers are light, and production is not in excess of consumption. The latter remains on a good scale, and all works are busy. Current quotations:—*Cash*: Thursday, £219 10s.; Friday, £214 15s.; Monday, £206; Tuesday, £201 10s.; Wednesday, £206 10s. *Three Months*: Thursday, £218 17s. 6d; Friday, £214 5s.; Monday, £205 10s.; Tuesday, £201; Wednesday, £206 5s.

Spelter.—Some improvement may be noted in the market for this metal during the past week, buyers evidencing slightly more interest than of late, while consumptive demand is also on a more active scale. Current quotations:—*Ordinary*: Thursday, £31; Friday, £30 17s. 6d.; Monday, £30 12s. 6d.; Tuesday, £30 8s. 9d.; Wednesday, £30 7s. 6d.

Lead.—The market for soft foreign pig remains in a very unsettled condition, consequent on liquidation and bear selling, and buyers have generally adopted a very reserved attitude. Consumption is still good and a rather better demand is reported on the Continent. Current quotations:—*Soft foreign (prompt)*: Thursday, £29 12s. 6d.; Friday, £29 10s.; Monday, £29 2s. 6d.; Tuesday, £28 15s.; Wednesday, £28 15s.